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FEASIBILITY OF SELECTED SYSTEMS FOR UNITIZING 10-POUND BAGS OF POTATOES

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

FOREWORD

The function of the Transportation and Facilities Reserach Division of the Agricultural Research Service is to find ways to increase the efficiency and reduce the cost of moving farm and food products from farms to consumers. This is accomplished by determining and bringing about the adoption of the most efficient methods, facilities, and equipment for moving the products through distribution channels.

This report covers the results of research done under contract by Food Industries Research and Engineering, Inc., of Yakima, Wash., to find more efficient, less costly ways to package, transport, and handle potatoes in consumer-size bags. Specifically, the work sought to determine the feasibility of unitizing, automatically and semiautomatically, 10-pound bags of the product. This publication contains the contractor's report substantially as it was submitted to the Division.

It is our hope that the information in this report will assist the potato industry in making significant economies through improved methods of unitizing consumer-size bags and that the report will also be useful to handlers of other products that are packed in consumer-size bags.

William C. Crow
Director
Transportation and Facilities
Research Division
Agricultural Research Service

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Consumer and Marketing Service,
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Chicago, Ill.

Red River Valley Potato Research Center,
East Grand Forks, Minn.

Potato Packinghouses

Great Atlantic & Pacific Tea Company, Inc.,
Burley, Idao

Pacific Fruit and Produce,
Othello, Wash.

Scone & Conners,
Warden, Wash.

Baker Produce,
Kennewick, Wash.

Basin Produce,
Moses Lake, Wash.

Anderson Produce,
Othello, Wash.

Associated Potato Growers, Inc.,
Grafton, N. D.

Drayton Potato Co.
Drayton, N. D.

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Terminal Markets

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Great Atlantic & Pacific Tea Company, Inc.,
Chicago, Ill.

Suppliers

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Seattle, Wash.

Bemis Bag Company, Inc.,
Seattle, Wash.

Borden Chemical Company,
North Andover, Mass.

Cello Bag,
Turwila, Wash.

E. I. du Pont de Nemours and Company,
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FEASIBILITY OF SELECTED SYSTEMS FOR UNITIZING 10-POUND BAGS OF POTATOES

By Earl W. Carlsen, Patrick L. Freeman, and Philip L. Breakiron[1]

INTRODUCTION

This report describes and summarizes work done under a United States Department of Agriculture research contract to study and determine the feasibility of several alternative methods of unitizing 10-pound bags of potatoes. The general objectives were to explore methods of packaging and handling and the extent to which costs can be reduced by shipping potatoes in unitized bundles. The need for such unitizing is becoming increasingly apparent with the increases in labor and material costs, the growing scarcity of labor, and the reluctance of labor to perform heavy manual work. In addition, the results of this study may help to keep the produce industry abreast of the new economies being achieved in the durable goods industry, where products are automatically enveloped in shipping containers by form-on-line techniques.

The major experimental work of this study was on banding techniques. This work was done at the facilities of Food Industries Research and Engineering in Yakima, Wash.

A survey of facilities, packing methods, and costs of the potato industry was made in the Pacific Northwest and in the Red River Valley area of Minnesota and North Dakota. The pack-out volumes and the equipment needs of the potato packinghouses for unitizing bags of potatoes were determined from this survey.

An experimental shipment of potatoes in polyethylene film bags unitized in different sizes of bundles and with different types of banding material was made from Burley, Idaho, to Chicago, Ill. A similar experimental shipment using kraft paper bags was made from the Red River Valley in Minnesota to Urbana, Ill.

The report is designed to exceed the requirements of the contract. It is organized in this sequence: First, it discusses commercial practices and equipment needs and then reviews the trials that were made in unitizing methods, from which equipment requirements were tentatively established. Next, the report discusses the work on the shipments, both at the shipping point and in the markets, for each of the two experimental shipments—one from the Pacific Northwest and the other from the Red River Valley. Finally, it discusses the results of the study and gives conclusions, including suggestions for additional work that needs to be done to realize the potentials of the best method of unitizing bags of potatoes.

COMMERCIAL PRACTICES AND NEEDS

To gather background data for the study, a survey was made of the commercial bagging methods used in potato packinghouses. Several plants were visited. Packing, layout equipment, and methods were studied.

Layout and Capacity Requirements

The layout requirements and pack-out rates of the different Washington State and Red River Valley plants were analyzed. These layouts are shown in figures 1 through 9. The bagging capacity of these lines ranged from 1,200 to 3,000 bags per hour.

The packing-line equipment was found to have little effect on the work flow and rate of work of the unitizing operation since, within certain limits, the speed capacity of one operation could be adjusted to match the speed

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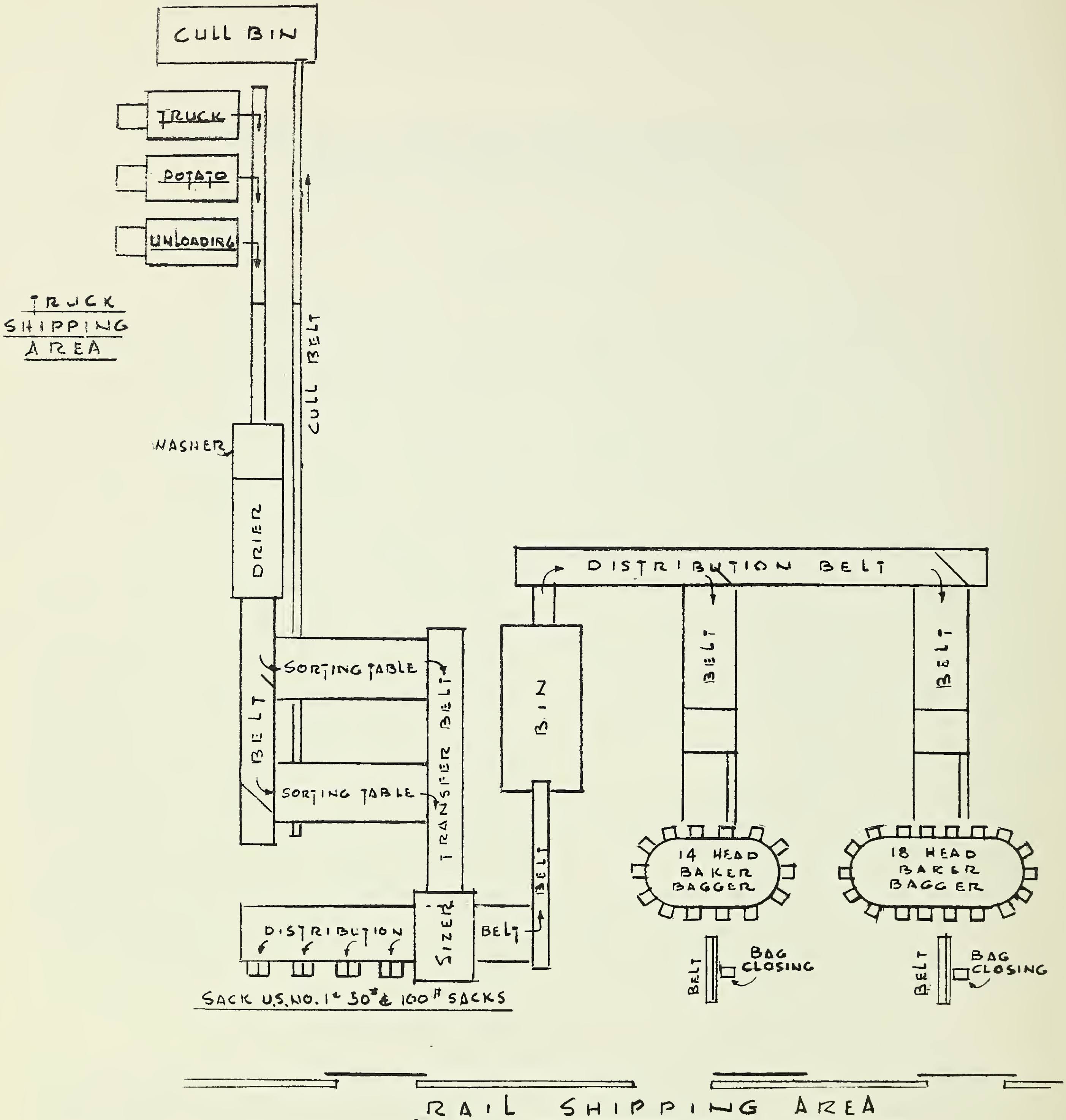


Figure 1.—Layout of a potato packinghouse with a pack-out rate of 1,800 10-pound bags per hour.

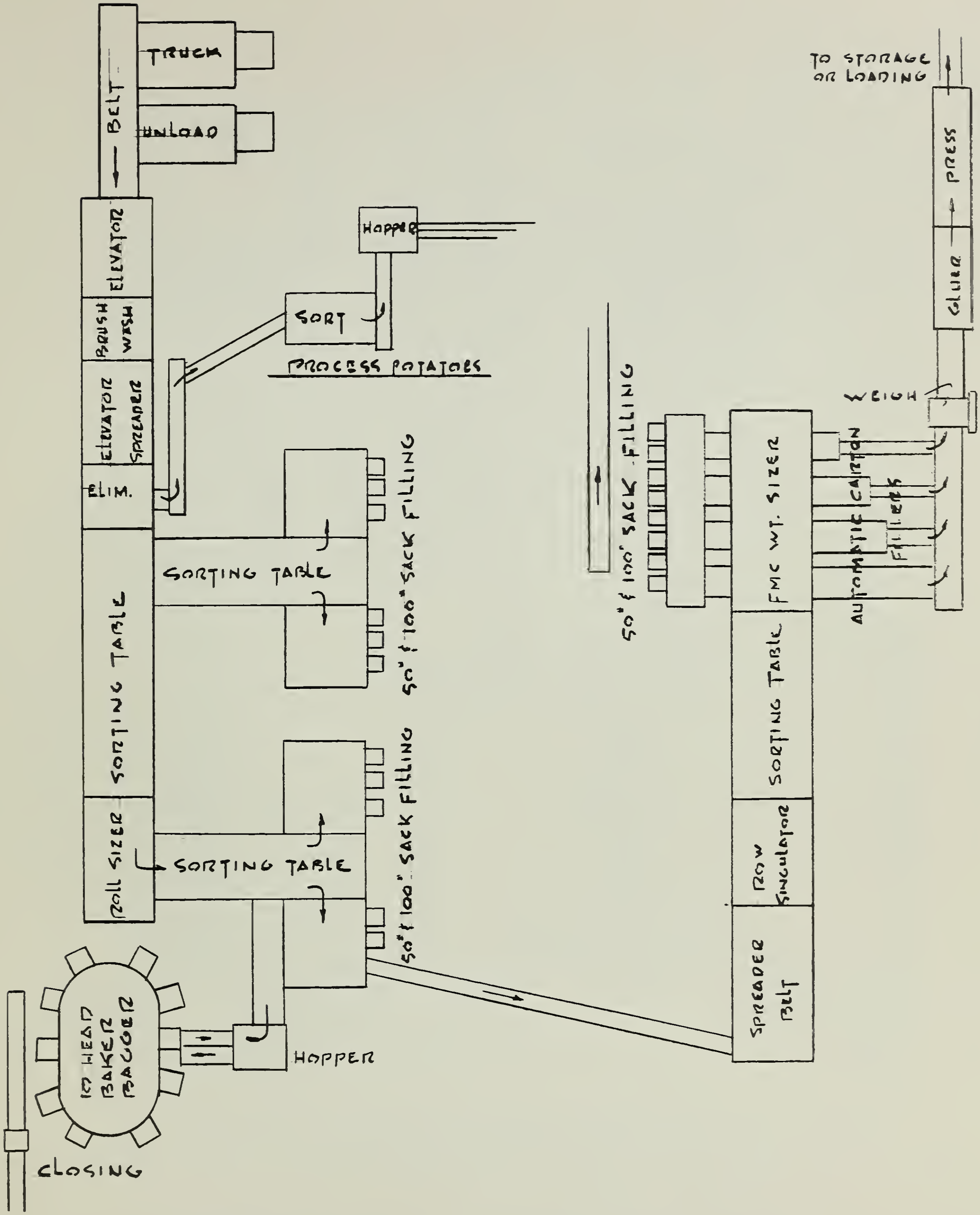


Figure 2.—Layout of a potato packinghouse with a pack-out rate of 1,800 10-pound bags per hour.

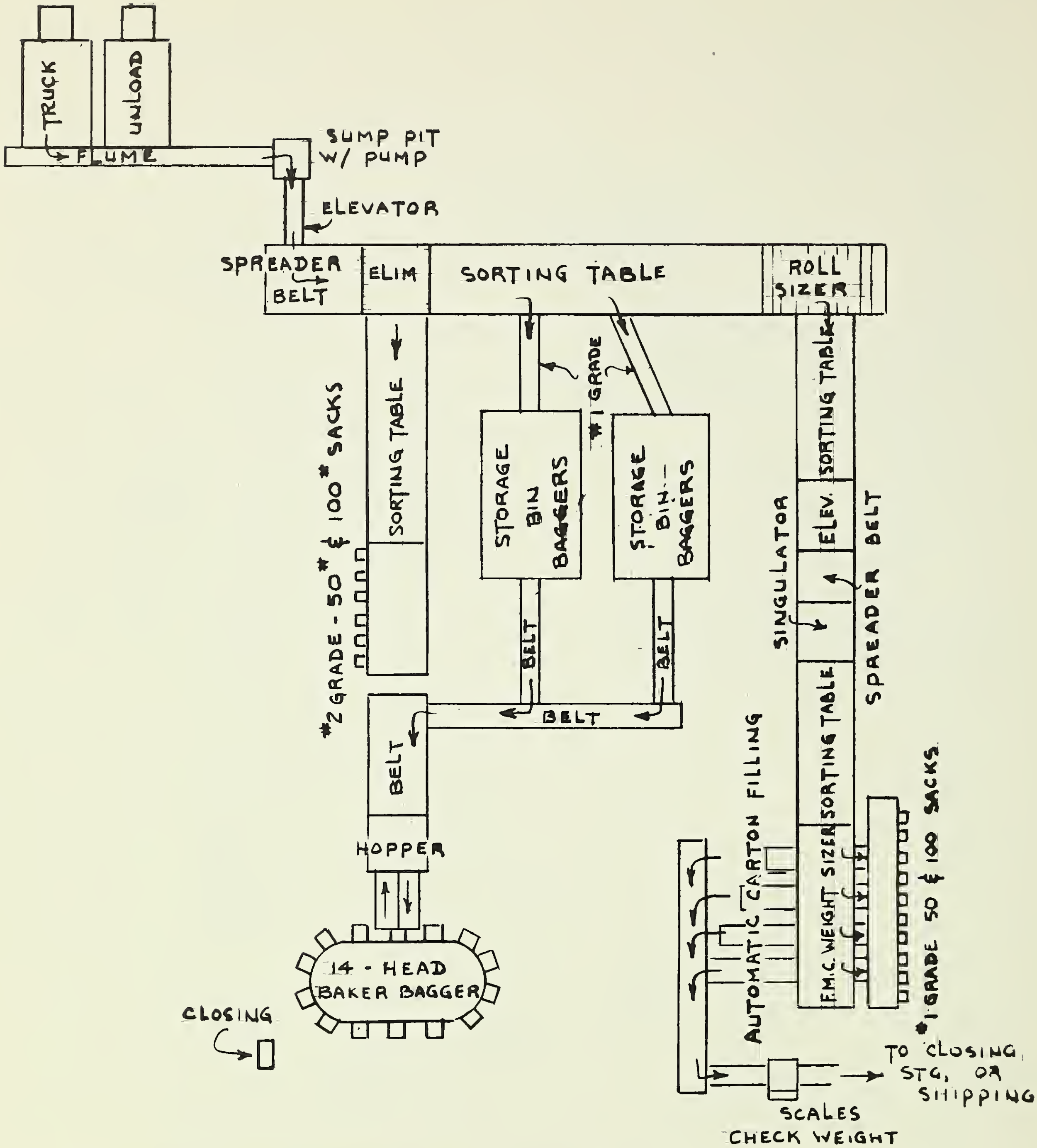


Figure 3.—Layout of a potato packinghouse with a pack-out rate of 1,200 10-pound bags per hour.

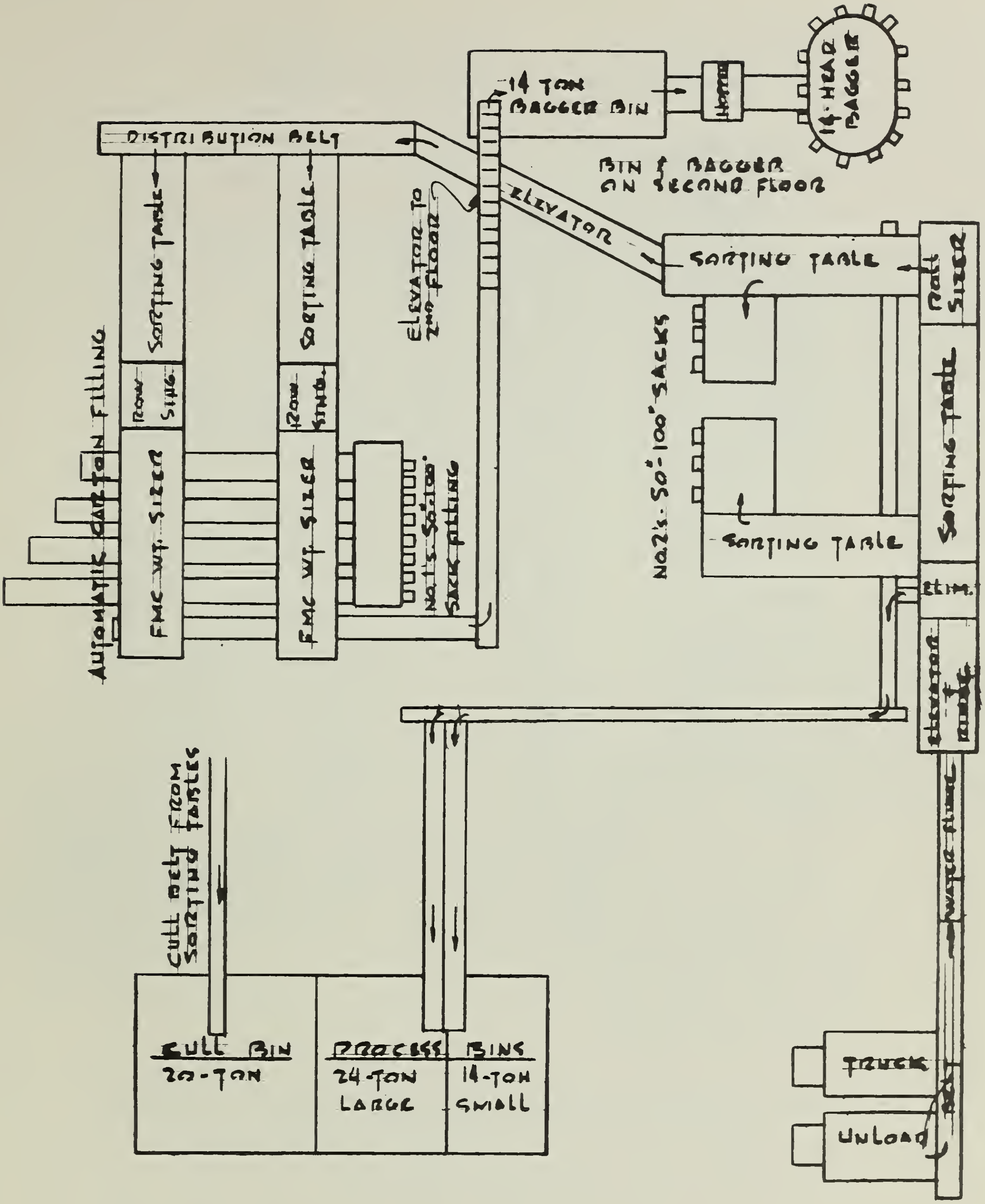


Figure 4.—Layout of a potato packinghouse with a pack-out rate of 1,500 10-pound bags per hour.

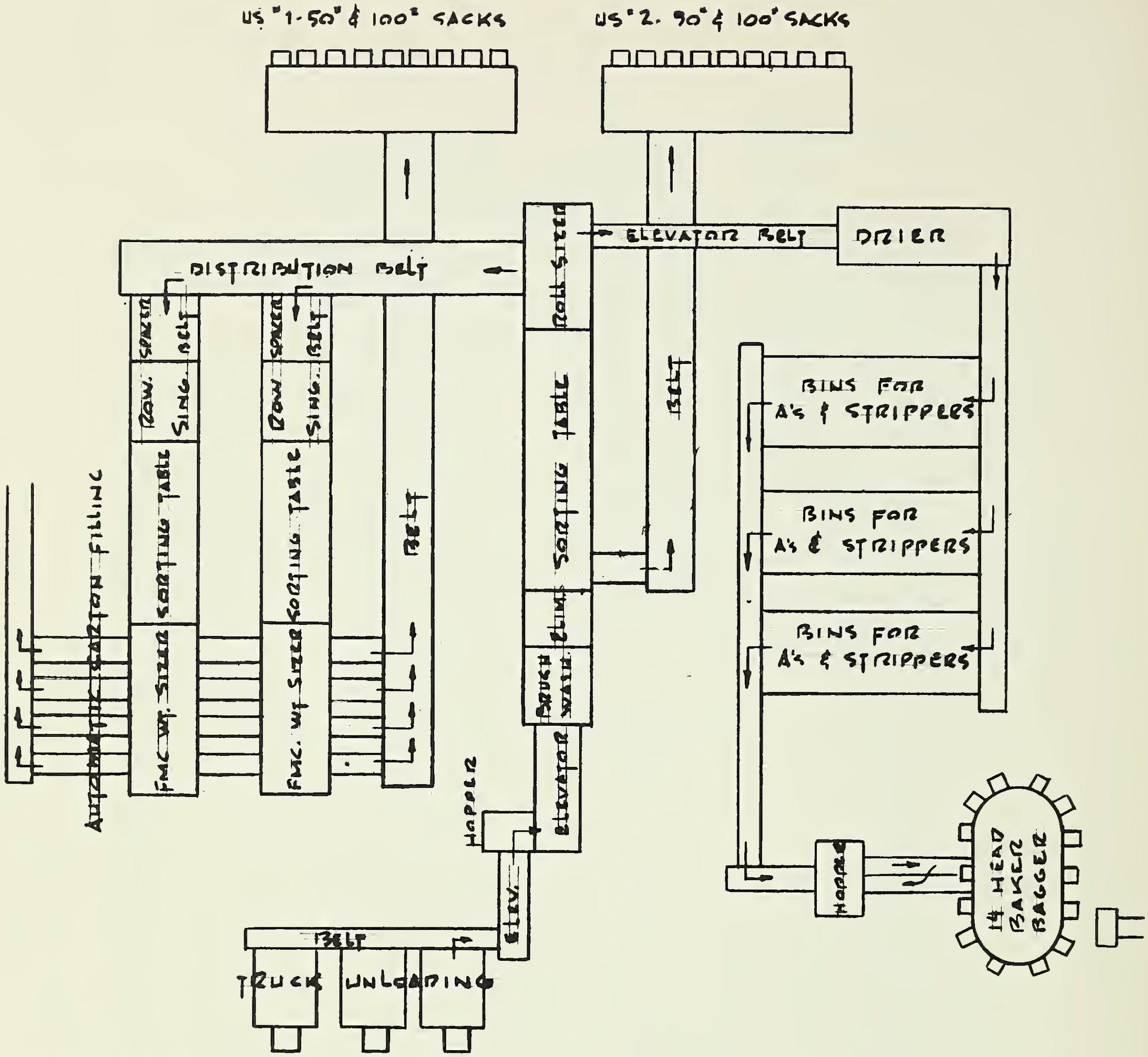


Figure 5.—Layout of a potato packinghouse with a pack-out rate of 1,500 10-pound bags per hour.

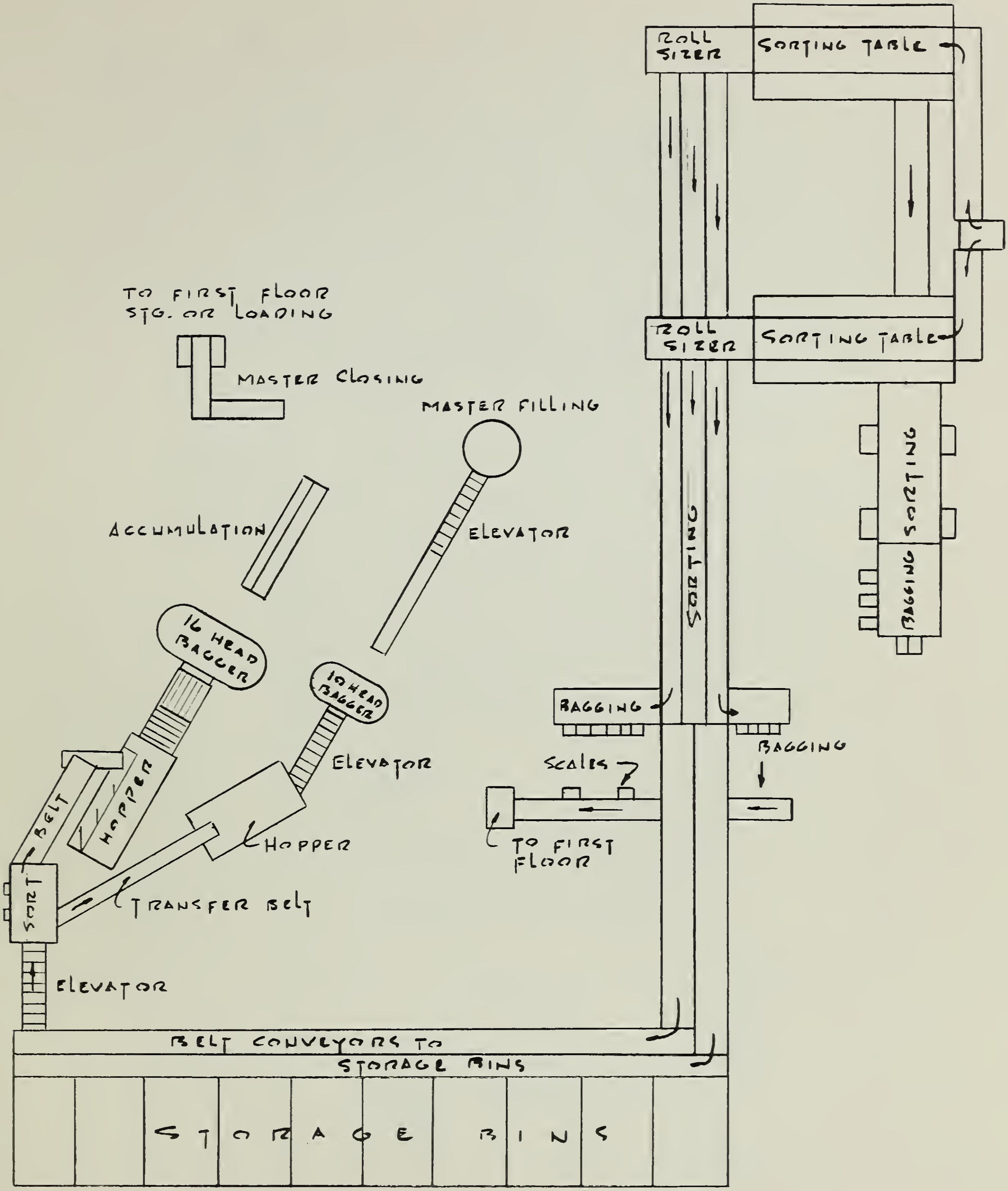
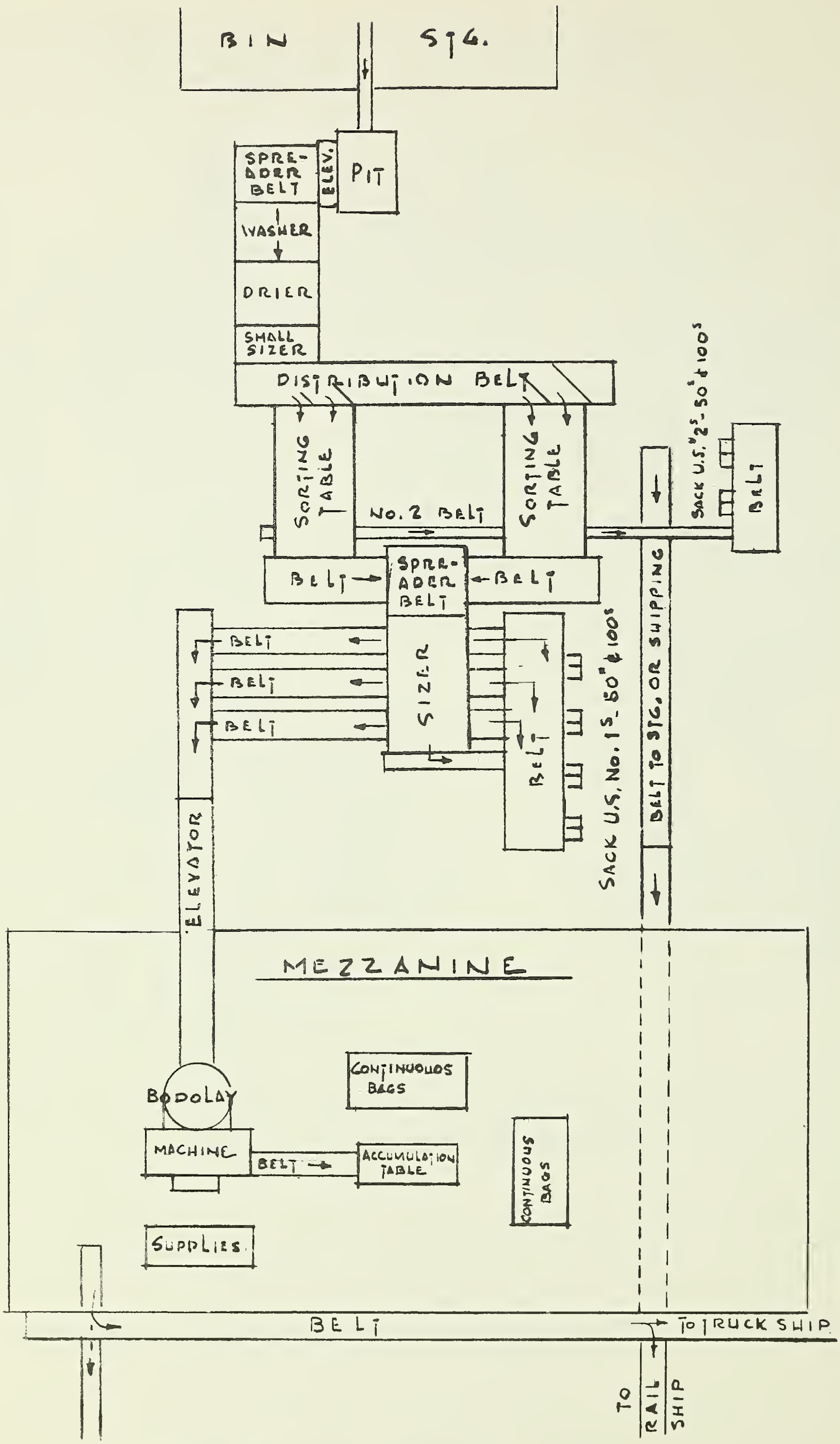


Figure 6.—Layout of a potato packinghouse with a pack-out rate of 3,000 10-pound bags per hour.



FORM, FILL, AND CLOSE CONTINUOUS BAGS

Figure 7.—Layout of a potato packinghouse with a pack-out rate of 1,400 10-pound bags per hour.

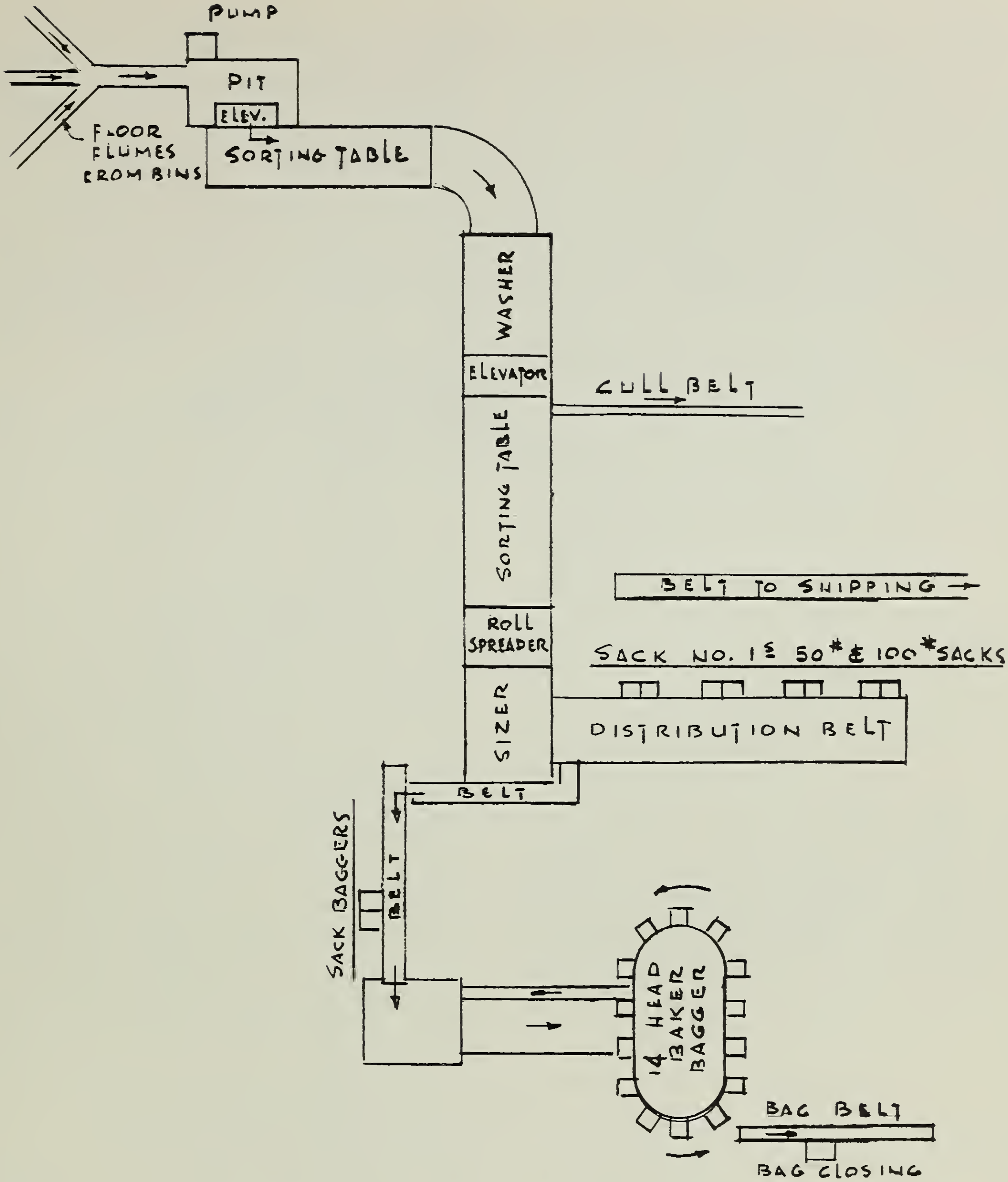


Figure 8.—Layout of a potato packinghouse with a pack-out rate of 1,400 10-pound bags per hour.

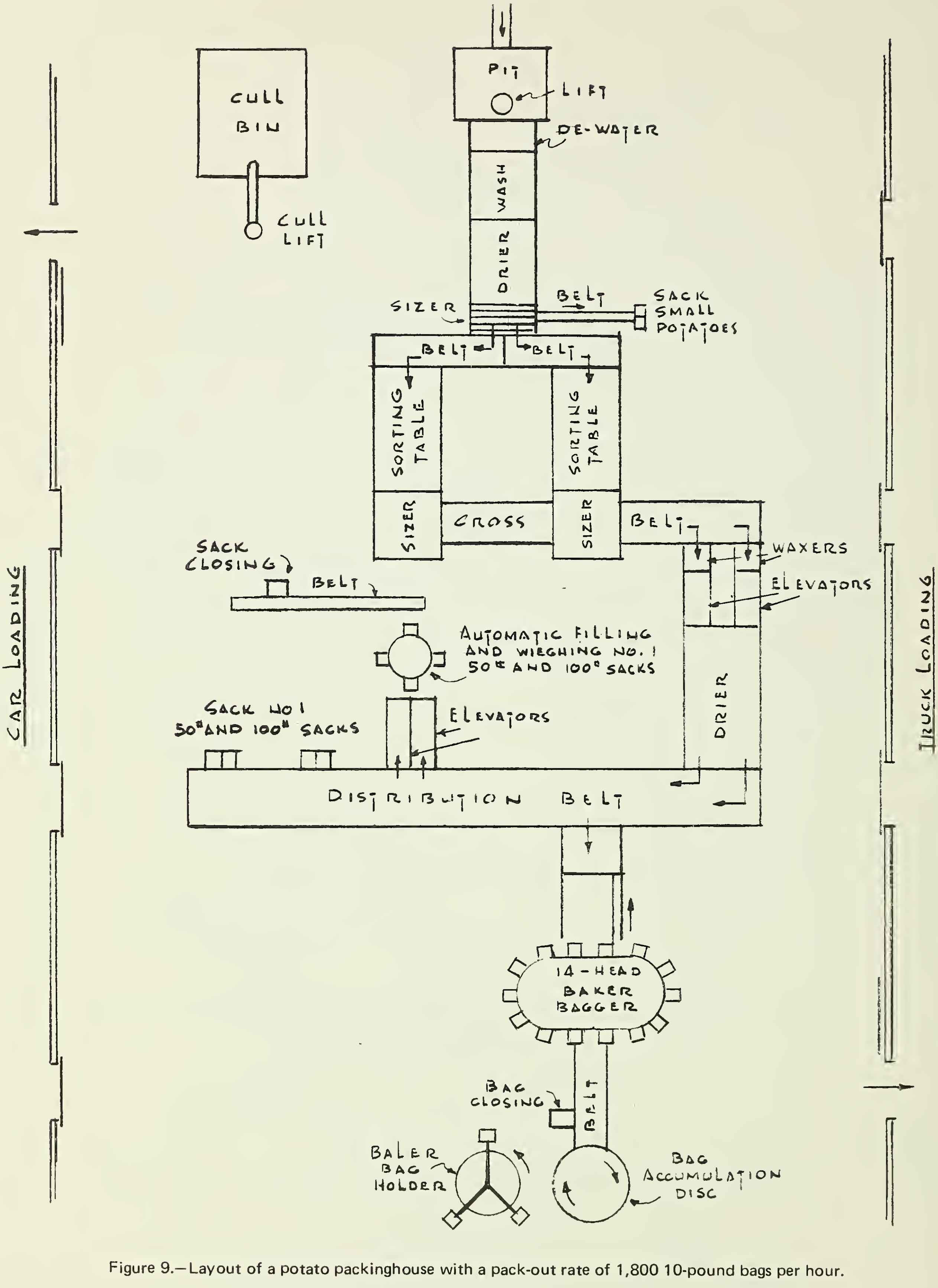


Figure 9.—Layout of a potato packinghouse with a pack-out rate of 1,800 10-pound bags per hour.

capacity of the other operation. Research workers of the Red River Valley Potato Research Center classified the plants in that area as follows:

Rate Per Hour	*Size Classification*
50 - 70 cwt.	Small
200 - 225 cwt.	Medium
550 cwt. and over	Large

The capacity of the plants surveyed in Washington State ranged from 30 to 40 tons per hour, which was larger than the capacity of the plants in the Red River Valley. Equipment and layout features required for unitizing would, therefore, best be designed for meeting needs of large plants. However, the total input of potatoes to a packinghouse does not appear to be the factor that determines the output of the bagging operations. Nearly always a potato packing line is turning out more than one pack or grade of potatoes at one time, and therefore, only part of the total volume may go to the point where the consumer-size bags are packed. The larger plants in Washington State operate with intermediate storage bins where the appropriate sizes of potatoes for bagging are held until the orders come in, or until the volume is sufficient to operate the bagging line at capacity. This operating practice evens out the flow of the potatoes and allows the section of the packing line on which the consumer-size bags are packed to operate at a uniform pace.

The pack-out rates and layout requirements for the consumer-bag part of the packing line are determined by the volume of input to the line, which cannot exceed design limits.

Baker Bagger, the Key Element

The most common type of bagging equipment used in potato packinghouses, both in terminal markets and producing areas, is the Baker bag-filling machine (fig. 10) originally developed and manufactured by a firm in Kennewick, Wash. This equipment is composed of a number of bag-holding devices in which the bags are held in open position on a scale. The bag holders move on a continuous chain on an oval track. The potatoes are fed into the bags on one side of the oval, while on the other side the bags are removed and transferred to a closing station. Workers must be at hand to check the weight of the potatoes in the bags, to help with the transfer to a closing device, and sometimes to place the empty bags in the holders. Film bags may be placed in and removed from the bag holders automatically.

The bagging setup may operate directly from a storage bin, which holds potatoes in the right grade and size so that the rate of feeding the potatoes to the bagger can be regulated. There are other versions of the bagger that have a temporary return-flow conveyor-and-bin system that holds a reserve supply of potatoes. This reserve supply is a buffer in that it holds a sufficient capacity to enable a bagger to operate at or near full capacity when the potatoes are fed directly from a potato-grading operation. This type of bagger can also be used in terminal markets where potatoes may be fed into the machine from 100-pound sacks.

The capacity of the Baker bagger is determined partly by the number of bagging heads on the unit. Variations of the machine having from 10 to 16 bagging heads were operating in the Washington State potato packinghouses. A typical layout of the Baker bagger is diagramed in figure 11.

Bag Sizes

The polyethylene film bags most commonly used in potato packinghouses surveyed were either 12 inches wide by 19 inches long or 11 inches wide by 22 inches long. Bags had twenty-four 1/4-inch ventilation holes. Therefore, most of the experimental unitizing work was done with these two sizes. The continuous form-and-fill plastic polyethylene film baggs that were fabricated especially for experimental use were 11 1/2 inches wide.

The kraft paper bags used were 7 3/4 inches wide by 16 3/4 inches long, with a 4 3/4-inch gusset.

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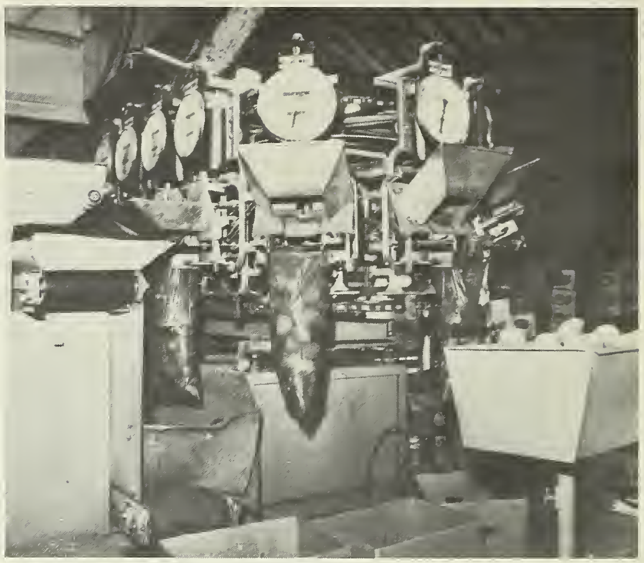

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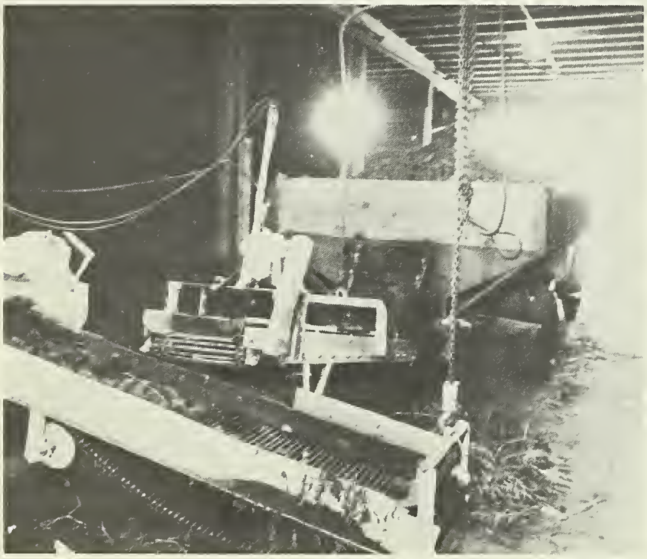

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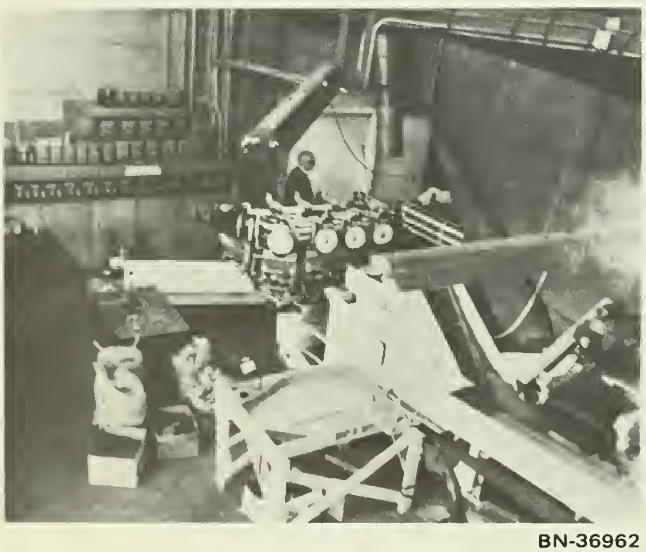

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Figure 10.—Typical equipment and operations in potato packinghouses in Washington State. A, Filling 50-pound packinghouses in Washington State. A, Filling 50-pound bags of potatoes. B, Baker bagger unit filling 10-pound bags of potatoes. C, Truck dumping potatoes directly onto line. D, Typical equipment leading to Baker bagger. E, Top view of Baker bagger. F, 50-pound master containers stacked in rail car.

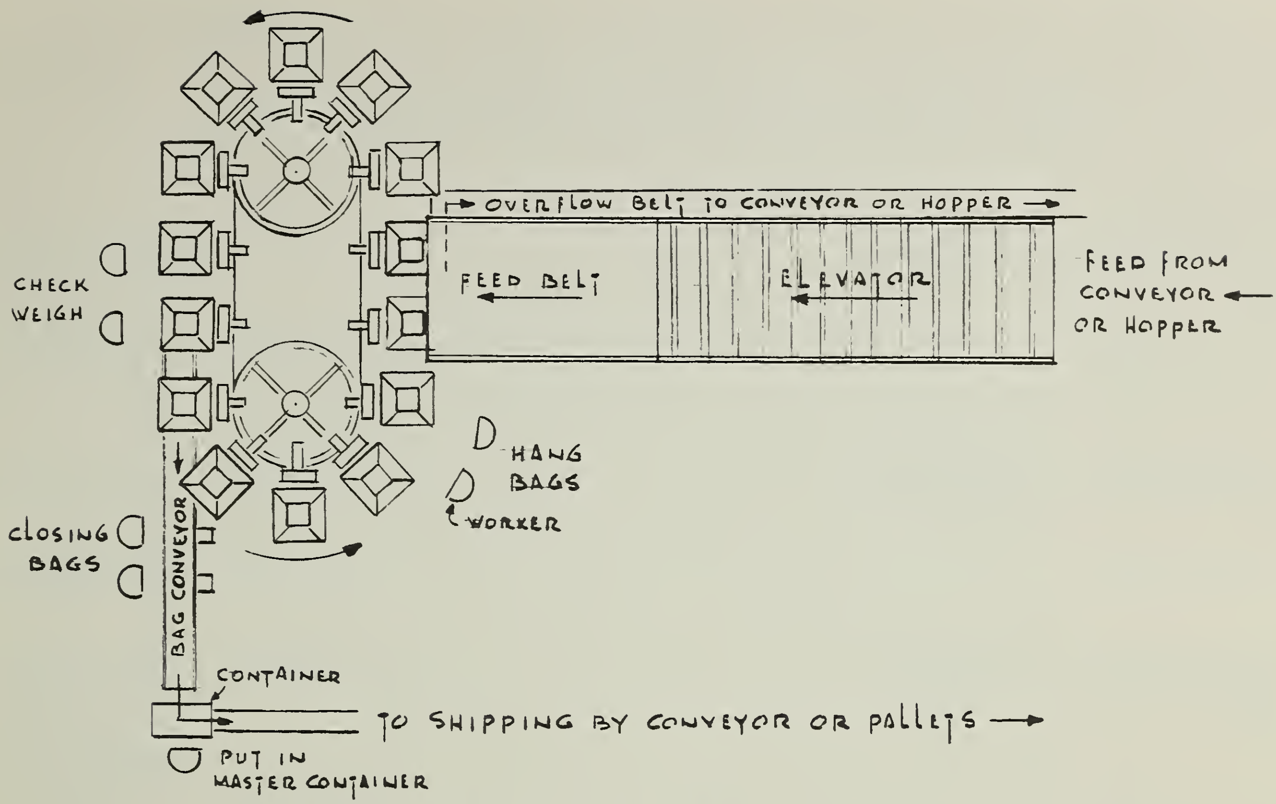

Figure 11.—Typical layout, in potato packinghouse, of bagging equipment for packing 10-pound bags.

ESTABLISHING UNITIZING METHODS AND REQUIREMENTS

For carrying out the provisions of the contract, nearly all major national supplies of films or bagging materials were contacted. They were most cooperative in supplying testing materials and technical information. The use of some of the materials did not prove to be as simple as had at first appeared. Results indicated that a broader approach to the selection and use of the materials used to bind the bags together was required and that perhaps new materials should be tried.

Experiments in banding the bags together into units containing four, five, or six 10-pound bags held together with different types of banding material were made in the experimental shop before making the experimental shipments and performing unitizing operations in a potato packinghouse. The first banding trials were made with polyethylene film bags, because these were to be included in the first test shipment. The best of the banding techniques were used for unitizing paper bags for the second test shipment, from the Red River Valley.

Trials With Four Unitizing Methods

The bags were filled by hand with potatoes weighing from 4 to 10 ounces. The polyethylene baggs were filled with the Russett Burbank variety, and the kraft paper bags with the Diamond Red variety. This size of potato is known in the industry as a "stripper." The average weight of the potatoes per bag was 10 1/2 pounds, which allowed for one-half pound of shrinkage in transit and marketing.

Most of the film bags were closed manually by twisting wire around the necks of the bags. The continuous bags, however, were heat-sealed. The mouths of the regular kraft paper bags were closed by sewing; those on the experimental continuous kraft paper bags were stapled.

To facilitate unitizing the bags into handling units of different sizes, a special V-shaped rack was developed for holding the bags in place while they were banded. The types, sizes, characteristics, and performance of all the banding materials tested are shown in table 1.

TABLE 1.—Types, sizes, characteristics, and performance of banding materials and sealing methods tested

Banding materials tested	Method of sealing	Polyethylene bags		Paper	Adequacies			Performance
		9" x 12"	22" x 11"	16¾" x 12½"	Good	Fair	Poor	
High-strength plastic bands:								
5/8-inch-wide plastic band, Avistrap (FMC Corp.).	Tool-tightened and crimped metal clip.	x	x	x		x		When tightener was released, bands were left loose. One band used on short bag, two on long. Bands slipped on polyethylene bags.
5/8-inch-wide plastic band, Avistrap (FMC Corp.).	Hand-tightened and tool-crimped metal clip.	x	x	x	x			Moderately tight package with both polyethylene and paper. One band used on short bag, two on long. Bands slipped on polyethylene bags.
5/8-inch-wide plastic band, Avistrap (FMC Corp.).	Hand-tightened, then stapled.	x	x	x			x	Staples tore loose and shredded bands. One band used on short bag, two on long. Bands slipped on polyethylene bags.
5/8-inch-wide, 5-mil polyethylene band (Union Carbide Corp.).	Heat-sealed	x					x	Film stretched.
Fiber bands:								
3/4-inch-wide cord strapping, Avistrap (FMC Corp.).	Cinch clipped ...	x		x		x		Strap rolled up; made loose package.
3/4-inch-wide cord strapping, Avistrap (FMC Corp.).	Hand-tied knot ..	x				x		Strap rolled up; made loose package.
3/4-inch-wide cord strapping, Avistrap (FMC Corp.).	Stapled	x					x	Strap rolled up; made loose package.
3/4-inch-wide cord strapping, Avistrap (FMC Corp.).	Tool-crimped metal clip.	x		x		x		Strap rolled up; made loose package.
6-inch-wide woven Fiberglas mesh, (Owens-Corning Fiberglas Corp.)	Stapled	x					x	Staples tore loose; mesh rolled up.
3 1/2-inch-wide jute webbing, No. 9 strength (Van Waters and Rogers, Inc.).	Stapled	x		x		x		Units loosened up when picked up by hand.
3/4-inch-wide filament tape (3 M Co.).	Self-sealed by adhesive tape.	x		x			x	Tore bags when removed.
3-inch-wide woven nylon elastic band (Canton Elastic)	Stapled	x					x	Stretched too much.

TABLE 1.–Types, sizes, characteristics, and performance of banding materials and sealing methods tested (Continued)

Banding materials tested	Method of sealing	Polyethylene bags		Paper	Adequacies			Performance
		9" x 12"	22" x 11"	16¾" x 12½"	Good	Fair	Poor	
Fiber bands-Con.:								
3 1/2-inch-wide jute webbing, No. 6 strength (Van Waters and Rogers, Inc.).	Stapled	x		x		x		Rolled up and staples came loose.
9-inch-wide burlap (Ames Harris Neville Co.).	Stapled	x		x		x		Could not be tightened enough; staples did not hold.
3/4-inch-wide polyester reinforced tape, Scotch Brand (3 M Co.).	Self-sealed by adhesive tape.	x		x			x	Tore bags when removed; rolled up.
3-inch-wide gummed paper tape-nylon strands, kraft paper.	Adhesive tape (all around bags).		x	x		x		When adhered full length, tore bag.
3-inch-wide gummed paper tape-nylon strands, kraft paper.	Adhesive tape (on end only).		x	x	x			Held very well; bags loosened slightly.
Heat-shrinkable plastic bands[1]:								
5-inch-wide, 5-mil shrink film (Union Carbide Corp.).	Heat-sealed	x	x	x			x	Broke near seal and welded to polyethylene bags.
5-inch wide, 5-mil shrink film (Union Carbide Corp.).	Heat-sealed–paper between banding material and bag to prevent welding to polyethylene bag.	x	x	x			x	Broke.
5-inch-wide, 3-mil shrink film (Union Carbide Corp.).	Heat-sealed	x	x	x			x	Not heavy enough gage; broke.
16-inch-wide, 1 1/2-mil shrink film, Cryovac (W.R. Grace Co.).	Heat-sealed	x					x	Broke; too light.
15-inch-wide, 3-mil shrink film (E.I. du Pont de Nemours and Co.).	Heat sealed (one band).		x	x			x	Not heavy enough, welded to polyethylene bags.
15-inch-wide, 3-mil shrink film (E.I. du Pont de Numours and Co.).	Heat-sealed (two directions).		x	x		x		Process too long with bands in two directions.
24-inch-wide, 5-mil shrink film (Union Carbide Corp.).	Heat-sealed		x	x	x			Film shrank unevenly, but held well.
15-inch-wide non-stretch film (Union Carbide Corp.).	Heat-sealed		x				x	Did not hold weight of units.
22-inch-wide, 2-mil polyvinyl chloride (Reynolds Metals Co.).	Heat-sealed		x	x	x			Shrank rapidly at low temperature. Should be slightly heavier gage.

TABLE 1.–Types, sizes, characteristics, and performance of banding materials and sealing methods tested (Continued)

Banding materials tested	Method of sealing	Polyethylene bags		Paper	Adequacies			Performance
		9" x 12"	22" x 11"	16¾" x 12½"	Good	Fair	Poor	
Multibag units:								
2 1/2-mil polyethylene bags (Shields Bag Co.).	Heat-sealed		x		x			Verry good.
Kraft paper bags taped together (Bemis Bag Co.)[2]	Kraft adhesive paper			x			x	Adhesive bond tore from bag.
Kraft paper bags taped together (Bemis Bag Co.)[2]	Elmer's glue on kraft tape with nylon strands.			x			x	Asphalt bond of tape separated.
Kraft paper bags taped together (Bemis Bag Co.)[2]	Elmer's glue on kraft tape with nylon strands.			x	x			Held well when unit was folded with tape to outside.

[1] All film is polyethylene tape unless otherwise specified.
[2] Simulated mechanical fabrication of multibag units.

Trials with Plastic Bands

The initial banding trials with high-strength plastic bands were unsuccessful. It was difficult to get the bands tight enough to hold the bags in a compact unit, especially when tightening and crimping tools were used. When the units were handled, the potatoes shifted to different positions inside the bags and slackness developed in the unit. The lack of sufficient friction between the film and the plastic band often allowed the bags, particularly the shorter polyethylene bags, to slip out of the bundles. When the trials were repeated with a longer bag, it was found that two bands would hold satisfactorily when the strap was hand tightened and sealed with a crimping tool. There was less difficulty of this type with the paper bags.

It was found that a single band, 15 inches wide or wider, placed around the center of a bundle of bags was satisfactory for holding the unit together. The slackness that developed during the handling of the units was not sufficient to allow the bags to slip out from under the bands because the potatoes were evenly distributed in the bags.

When narrow bands (5/8-inch to 3/4-inch wide) were used, however, the pressure around the center of the bags caused the potatoes to shift toward the ends of the bags. This shifting caused distortion in the shape of the bags, which remained after the band was removed.

Banding trials with a 5-mil polyethylene band were not successful because the film stretched during handling. It is possible that manufacturers could turn out a film with nonstretch characteristics that would prove satisfactory for this purpose.

Much difficulty was experienced in attempting to handle the completed units on pallets. When the banded units were stacked on pallets, they produced unstable pallet loads which spilled easily during handling. Pallet loads of units of the kraft-paper bags were more stable than pallet loads of units of polyethylene film bags.

The four- and six-bag units "squared-up" better in unitizing than the five-bag units, they were easier to stack on the pallet, and they made more stable pallet loads. These differences between the unit sizes were more pronounced with the kraft paper bags than with the polyethylene film bags.

Trials with Fiber Bands

Banding experiments with several types of commercially available fiber strapping materials where not successful for some of the same reasons as in the trials with the high-strength plastic bands.

The surface of the fiber strapping was too slick to hold the polyethylene bags in place in

the units. Somewhat better results were obtained with the fiber bands when they were used on paper bags.

Stapling the ends of the fiber strapping together was unsuccessful, because the staples pulled out of the material when the fiber strands near the ends of the straps became separated. This problem might be overcome by the use of an improved staple. The ends of the fiber strapping could be fastened together only by metal clips or hand-tied knots, which presented a potential damage hazard to the potatoes. In addition, fastening by either of these methods was rather slow. Therefore, different types of fiber banding were tried.

A loose-woven Fiberglass mesh manufactured by Owens Corning Fiberglas Corp. and used in roofing applications was tried. This material might be satisfactory if a successful method of fastening the ends together could be found. Stapling the ends together was not satisfactory because the staples came loose during the handling of the units. If is possible that the material could be sealed by some type of adhesive.

Banding trials with jute webbing of the type used in the upholstering industry gave a small degree of success. The webbing, however, was of a heavier and, consequently, more expensive gage than needed. For this reason, burlap stripping was tried. This material held the bags satisfactorily, but no satisfactory means of fastening the ends together could be found. Use of special stapling or adhesive may provide an acceptable means.

Among the fiber materials tried was a woven nylon elastic band, which stretched excessively. Furthermore, the band tended to roll up into a narrow rope-like piece when the units were handled.

The banding materials that gave the best results were reinforced kraft-paper tapes. One type of polyester material appeared satisfactory, except that the adhesive held the material to the bags so tightly that many bags were torn when the band was removed. No problem of this type was encountered in using the reinforced kraft-paper tapes. This material appeared to be the least expensive type of banding tried.

Palletized handling of the units banded together with fiber bands encountered the same difficulties as were encountered in handling the units banded with plastic bands.

Trials with Shrinkable Plastic Bands

It was found that shrinkable plastic bands could not be used on polyethylene bags, because a temperature high enough to shrink the band was also high enough to weld the banding material to the bags. Ways of avoiding this difficulty were sought.

Paper was placed between the shrinkable plastic band and the bags in an attempt to prevent the band from becoming welded to the bags. The band did not weld to the bags, but control of the rate of shrink was difficult. The cost of the paper and the difficulty and delay in using this method made it economically unattractive.

Film research laboratories indicated that polyvinyl shrink film shrinks at a temperature lower than that at which polyethylene shrinks. Subsequent banding trials with the polyvinyl film were successful. This material shrank easily and did not adhere to the polyethylene film bags.

Another method of preventing the shrink film from sticking to the bags worked fairly well. The film wraparound band was made wide enough that only the protruding ends needed to be shrunk to hold the bags in place in the unit. About 5 inches protrusion was found to be satisfactory. Results were found satisfactory for making shipping trials, even though the shrinking was done with hand-operated heating guns. Use of controlled temperature shrink tunnels should produce even better results than were obtained with the hand-operated, gun-type heaters.

Palletized handling of the units of bags banded with both types of plastic materials was as difficult as it was with the two previously described methods. The units of kraft paper bags were more difficult to handle than the units of polyethylene film bags.

Trials with Form-and-Fill Bags

Although the experimental continuous-bag units used in this research were made by hand for this work, one of the main problems was determining how the fabrication of this type of unit could be done by machine. After some experimentation, it was found that commercially available bag-making machines could be adjusted so that the continuous-bag units could be made on them. The bags made in this way were joined together at the side, since they were made from the same piece of plastic film. At these points on the continuous strip of film, the bags were

separated by about one-fourth inch where the film on one side of each bag was sealed to the film on the opposite side. Experiments showed that it was necessary to make the continuous bags one-half inch wider than the conventional film bags.

In handling the uunits, it was found that the bags could be folded over into compact bundles or could be stacked flat. The four- and five-bag units could be handled very easily without folding. However, it was necessary to fold the six-bag units for handling.

A method was developed for making form-and-fill paper bag units by using a fiber-reinforced kraft paper tape to which the conventional paper bags were glued. These units handled satisfactorily when the units were folded so that the bags were on the inside of the bundle and the flat side faced outward. When the continuous-bag units were folded on the outside of the strip, which was found to be more convenient for handling the five- and six-bag units, some of the bags pulled away from the tape. Fiber from the bag material adhered to the paper tape band when it was removed. The kraft paper bags were glued to the continuous strips of paper in a way that left a space of 1 inch between bags; at points on the strip where the units were to be folded the spacing was increased to 10 inches. This increased spacing between the bags allowed the length of the continuous banding to accommodate the width of two bags. With the four- and six-bag units, all of the space was left in the middle of the continuous banding; that is, with an equal number of bags on each side of the space so that the unit could be folded into a square or a rectangle. With the five-bag units, the space was left after the first two bags; that is, two bags on one side of the space and thee bags on the other. In handling, the five-bag unit tended to become more round in shape than the four and six-bag units.

For pallet handling the continuous-bag units were far superior to the other types of units tested, particularly the continuous film bag units; they were easily laid crosswise on the pallets without being folded, thus making a very strong pallet load. There was no instance of any of these units slipping from the pallets, even when they were stacked four or five units high.

Summary of Four Methods of Unitizing

The four best methods of unitizing were chosen for the shipping trials. These were:

1. Two bands of high-test plastic, hand tightened and crimped with a metal clip.
2. Kraft-paper tape reinforced with fiber.
3. Shrinkable plastic shrunk only on the ends so as to tie the bundle of bags together.
4. Continuous polyethylene-bag units with a narrow space between each bag, and continuous kraft-bag units with the bags held together by two reinforced fiber strips.

Equipment and Layout Requirements

Information on the commercial availability of the specialized equipment that might be used to unitize the bags by the four methods chosen for shipping trials was gathered from equipment manufacturers and suppliers. These data also were used to determine the probable floor space, labor, and material requirements for each method of unitizing the bags.

Manual Methods of Banding

One of the first findings of the experiments with manual methods of banding the bags into handling units was the need for a jig to hold the bags in place while the banding material was applied. A simple wooden rack was developed to meet this need (fig. 12).

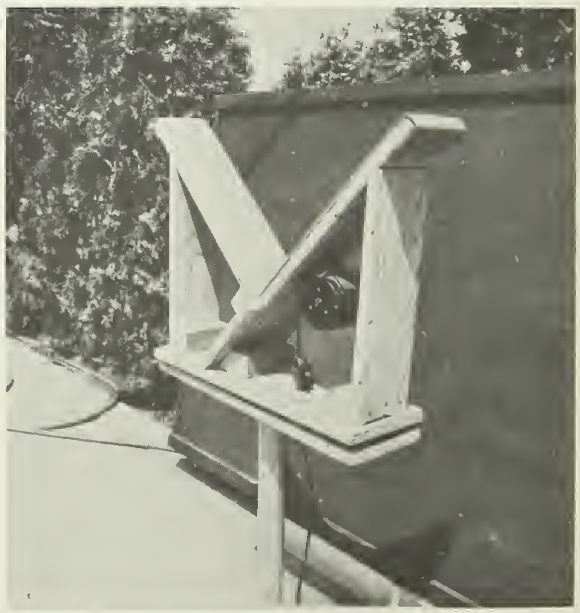

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Figure 12.—Banding fixture and stand used to unitize experimental shipments of potatoes.

Another finding of the experiments was that slackness developed in the units after the units were removed from the jig and handled several times. The problem was partly solved by attaching a vibrator to the bag-holding jig to shake the bags so the potatoes would settle into a more compact mass before the banding material was applied and sealed.

The bag-holding jig was found to be well suited for a hand-banding operation for such instances as when a commercial operator wishes to make trial or initial commercial shipments. It is designed to be placed at or near the end of the conveyor where an operator, with little effort, can slide and lift the bags onto the rack.

During the preparation of the units of bags for the shipping experiments, time studies were made of the different types of banding methods to obtain sufficient data for estimating worker productivity for each method of unitizing and each size of unit. Estimates based on these data are that the output would range from about 1,000 pounds per hour for the four-bag units banded with shrink film to about 2,000 pounds per hour for the six-bag units banded with fiber material.

Automatic and Semiautomatic Methods of Banding

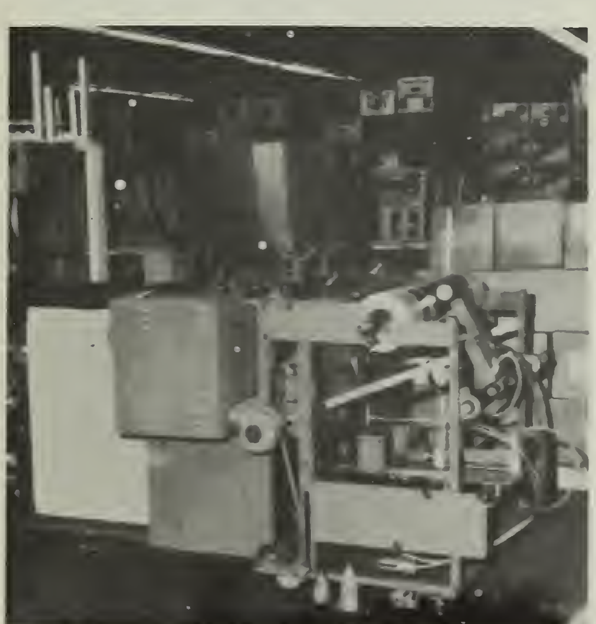
Automatic and semiautomatic methods of banding may be adopted for unitizing consumer-size bags of potatoes. The experimental results obtained in this research suggest that such banding could be accomplished by making some modifications in present commercial tying machines or bag form-and-fill equipment such as the Bodolay equipment illustrated in fig. 13. These machines have been designed to use standard banding and film materials.

Compatibility of Automatic and Semiautomatic Unitizing Equipment with Existing Equipment

The compatibility of automatic and semiautomatic unitizing equipment with existing packing-line equipment in the potato packinghouses surveyed in this study would appear to be quite satisfactory. The rated capacity of the form-and-fill equipment was almost equal to the rated capacity of the Baker bagger. The banding equipment unit is small enough that the use of conveyors with several units can give sufficient flexibility to a unitizing operation.

The banding equipment should be capable of operating at the highest capacity of a Baker bagger, but it could operate at a slower rate, when required, by changing the number of workers on the banding equipment and letting some equipment remain idle.

The form-and-fill equipment could be adjusted to run at a slower rate or to run intermittently. Thus, it should have complete



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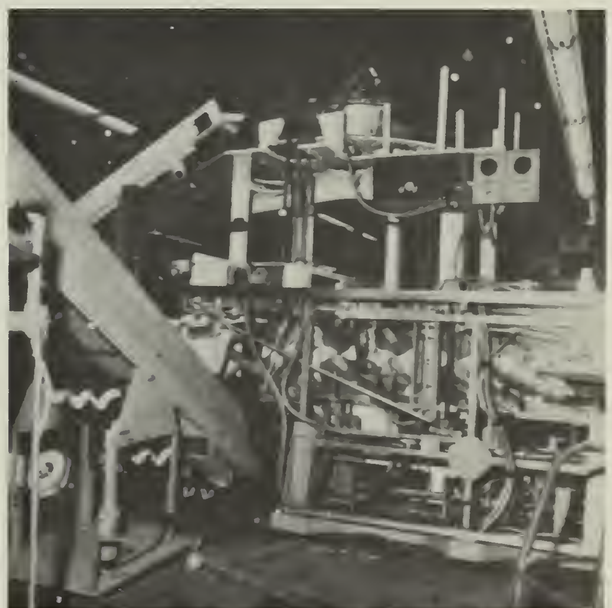

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Figure 13.—Two views of a form-and-fill machine for forming and filling 5-pound bags of potatoes.

compatibility with other parts of a potato packing-line operation.

Number of Workers Needed

Although this type of equipment is still being developed, it can be estimated conservatively that three workers would be required: One machine man to operate the automatic form-and-fill bag-making equipment, one filler attendant to handle the potatoes, and one pallet man to stack the completed units.

One operator per machine would be needed for the banding equipment. However, one man working at a normal pace cannot keep the machine running at its full capacity. Flexibility to meet peak demands can be gained by having three workers and three banding machines. For unitizing bags in five- and six-bag units, the same goal can be achieved by having two banding machines and three workers, two doing the banding and one assisting in the operation. The extra worker would serve as a relief man to give such assistance as the others required. This arrangement would provide an average work pace that would approach the normal rate of a potato-bagging line.

Work Flow To and From Machines

The materials used for banding the bags into units would be fed into the equipment from spools attached to the machine (fig. 14) or from rolls of film on the form-and-fill equipment.

The work space required for applying the banding would be about 300 square feet. It should be so arranged that the workers could place their output on a pallet immediately behind them (fig. 15). Pallets would need side racks to make stacking easier and to keep the units from falling off. With the automatic bag-making equipment, the continuous bags could be fed by a conveyor to a stacking station where one man could place them on pallets.

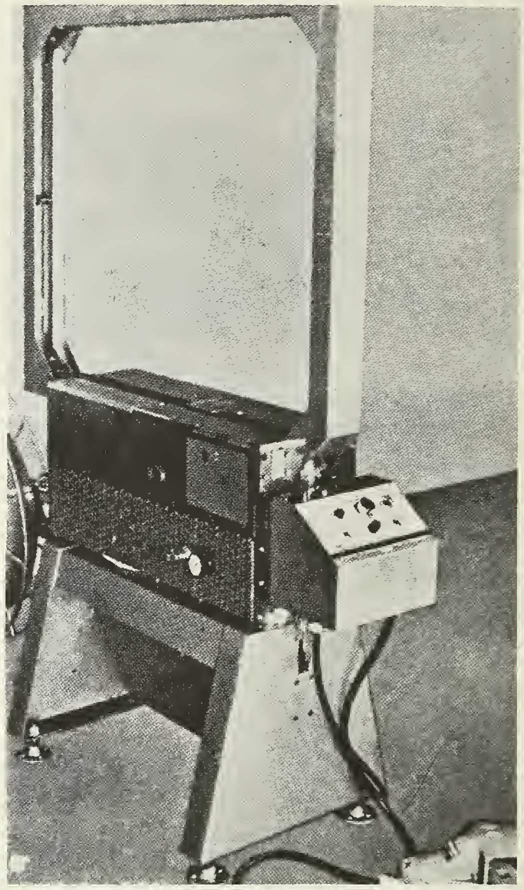

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Figure 14.—Banding machine for applying and sealing polypropylene banding material.

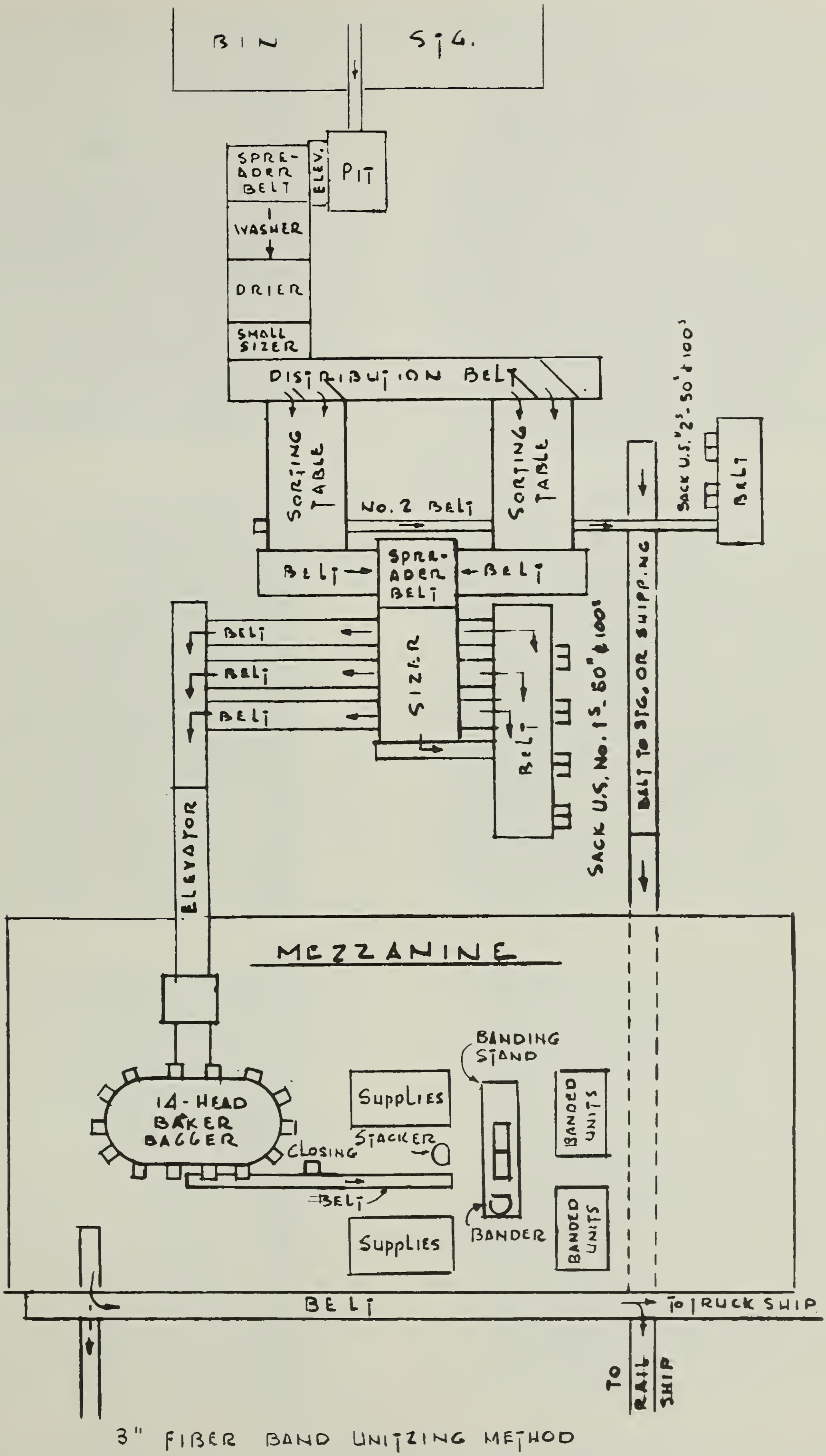

Figure 15.—Suggested floor layout for equipment used in unitizing 10-pound bags of potatoes in a typical potato packinghouse.

Layout of the Plant and Description of Operations at the Shipping Point

An experimental shipment of potatoes in unitized polyethylene bags was made from a potato packing plant in Burley, Idaho, on January 8, 1968. The plant handled 250 to 300 tons of potatoes a day. The best potatoes went to the fresh market, and the remainder were processed. The plant packing line had sizing equipment that sorted potatoes by their largest diameters, necessary conveyor distributing systems, and two Baker bagging machines.

The experimental shipment consisted of 240 units, or bundles—20 of each of three sizes (four-, five-, and six-bag units) unitized by each of the four banding methods (fig. 16). Thus, the 240 units were composed of eighty 4-bag units, eighty 5-bag units, and eighty 6-bag units. Half of each type and size of the experimental units were loaded in the forward quarter-length of the trailer and half were loaded in the rear quarter-length of the vehicle. Each size of unit unitized by each banding method was equally distributed in the bottom and the top layers of the load in the front and in the back of the vehicle. The middle of the load was made up of un-unitized 10-pound bags to fill out the shipment. The toal weight of the load was approximately 30,000 pounds.

It was necessary to load the experimental shipment of potatotes into the truck from a single loading station next to the area where incoming trucks were unloading. The truck-loading facilities did not include a truck-bed height loading dock, which posed handling difficulties and, in some cases, increased the stresses imposed upon the units as they were rehandled and lifted up to the truck trailer.

In loading the 50-pound conventional baler bags into rail cars, the bags were usually transported into the cars on two-wheel hand trucks fitted with large bag-retaining racks. This procedure could not be used for loading highway trucks because the truck-loading station was on the other side of the packinghouse. The unitized bundles of bags were loaded on pallets (fig. 17) and transported to the truck loading station by forklift truck for loading into the trailers.

The pallet loads for most of the load in the truck were lifted up to the bed of the trailer by the forklift truck and either rolled forward on a pallet dolly or carried by hand, one unit at a time, to their places in the load. To load the last three stacks into the truck, it was necessary to place the loaded pallets on temporary stacks of empty pallets on the ground outside the rear door and load the remaining units by hand from this point. In lifting the units of bags by hand from the pallets into the trailer, some of the units became loose, allowing some of the bags to slip out of place.

Cost Evaluations

The cost evaluations were made on the basis of actual operating figures obtained from the shippers or from commercial suppliers of equipment and materials. The wage rates used were those common in the area. Overhead and other cost factors were those that prevailed in the area where the packinghouses were located.

Costs were obtained for standard operations in the plant from which the shipment was made. Cost elements that might be peculiar to this plant, such as overhead and supervision, were not obtained from the cooperator. Instead, these figures are average costs for the area in which the plant was located.

Materials Cost Evaluation

The materials cost for the different types of units did not vary greatly except for the continuous-bag unit. Materials costs for the continuous bag were less than half of comparable costs for other unitizing methods (table 2).

Labor Cost Evaluation

The labor cost for the shipment of polyethylene-bagged potatoes indicated that $0.07 direct labor went into each cwt. packed out. This was based on the applicable wage rate in the area of $1.94 per hour, including social security and insurance (table 3). Workers doing the unitizing were rated at $2.22 and a supervisor at $3.75 per hour. The wage rates shown in table 3 are converted in table 4 to labor costs for each method of banding and for each size of unit. Also included in table 4 are labor costs at projected wage rates.

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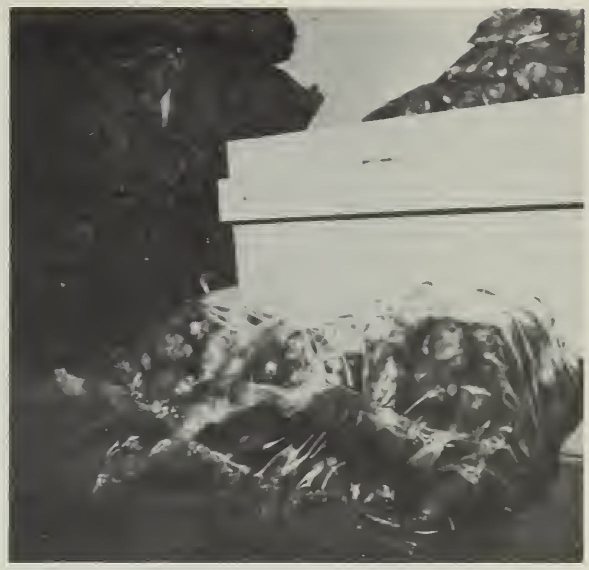

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Figure 16.—Polyethylene-bag units used in test shipments. A, Continuous bags. B, Continuous bags folded for handling. C, Shrink-film banded units stacked on pallet. D, Fiber-banded units stacked on pallet. E, Plastic-banded units stacked on pallet. F, Continuous bags stacked on pallet.

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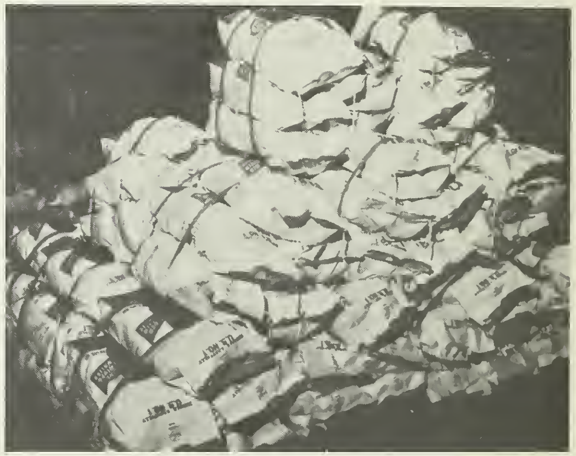

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Figure 17.—Polyethylene and paper-bag units used in test shipments. A, Handling a fiber-banded 4-bag unit of polyethylene bags. B, Shrink-film-banded units of polyethylene bags loaded in truck for shipment. C, Fiber-banded units of paper bags stacked on pallet. D, Plastic-banded units of paper bags stacked on pallet. E, Continuous-paper-bag units stacked on pallets. F, Shrink-film-banded units of paper bags stacked on pallet.

TABLE 2.–Material costs for unitizing 10-pound polyethylene bags of potatoes by banding method and number of bags in unit, Idaho, 1968

Banding method	Bag cost[1]	Banding material cost	Banding material cost per unit			Total material cost per unit			Total material cost per cwt.[2]		
			Four-bag unit	Five-bag unit	Six-bag unit	Four-bag unit	Five-bag unit	Six-bag unit	Four-bag unit	Five-bag unit	Six-bag unit
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
5/8-inch-wide plastic band. .	0.0331	0.0054/ft.	0.0468	0.0522	0.0576	[3] 0.1792	[3] 0.2177	[3] 0.2562	[4] 0.4480	[4] 0.4354	[4] 0.4270
3-inch-wide fiber band. . .	.0331	.00564/ft.	.0280	.0320	.0350	.1604	.1975	.2336	.4010	.3950	.3893
24-inch-wide shrink film. . .	.0331	.00007/sq. in.	.0800	.0890	.0990	.2124	.2545	.2976	.5310	.5090	.4960
16-inch-wide shrink film . .	.0331	.00007/sq. in.	.0580	.0650	.0720	.1904	.2305	.2706	.4760	.4610	.4510
Continuous bags · [5]	.0230	None	None	None	None	.0920	.1150	.1380	.2300	.2300	.2300

[1] Bag cost based on quantity order of 100,000 bags.
[2] Total costs include bags and banding materials, carried forward to table 16, page 40.
[3] Sample calculations:

Four-bag unit $\$0.0331 \times 4 + \$0.0468 = \$0.1792$
Five-bag unit $\$0.0331 \times 5 + \$0.0522 = \$0.2177$
Six-bag unit $\$0.0331 \times 6 + \$0.0576 = \$0.2562$

[4] Sample calculations

$$\frac{.1792}{.40} = 0.4480$$

$$\frac{.2177}{.50} = 0.4354$$

$$\frac{.2562}{.60} = 0.4270$$

[5] Cost of $0.023 per bag comes from manufacturer's price of $23.00 per thousand charged to Food Industries Research and Engineering.

TABLE 3.–Number of workers, hourly rates, and labor costs per hundredweight for bagging and unitizing 10-pound polyethylene bags of potatoes by type of labor, Idaho, 1968

Type of labor	Hourly wage[1]	Operational hrs./yr.	Yearly wage	Number of people	Total annual wage	Cost per cwt. @ 180 cwt./hr..
	Dollars	*Hours*	*Dollars*	*Number*	*Dollars*	*Dollars*
Ban hanger.	1.94	1,800	3,492.00	2	6,984.00	0.0216
Check weigher	1.94	1,800	3,492.00	1	3,492.00	.0108
Bag closer	1.94	1,800	3,492.00	2	6,984.00	.0216
Bag unitizer	2.22	1,800	3,996.00	1	3,996.00	.0123
Supervisor	3.75	[2]450	1,687.50	1	1,687.50	.0052
Total	–	–	–	–	23,143.50	0.0715

[1] Wage rates include fringe benefits.
[2] Based upon 25 percent of supervisor's time allocated to bagging operation.

TABLE 4.–Crew size and labor costs for unitizing 10-pound polyethylene bags of potatoes by banding method and number of bags in unit, one plant, Idaho, 1968

Banding method and number of bags in unit	Crew size					Total hourly labor cost		Total hourly labor cost per cwt.[4]	
	Bag hanger	Check weigher	Bag closer	Bag unitizer	Supervisor[1]	At prevailing wage rates[2]	At projected wage rates[3]	At prevailing wage rates	At projected wage rates
5/8-inch-wide plastic band:	*Number*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
4-bag unit. . . .	2	1	2	[5] 3	0.25	17.30	17.75	0.0961	0.0986
5-bag unit. . . .	2	1	2	[5] 3	.25	17.30	17.75	.0961	.0986
6-bag unit. . . .	2	1	2	[5] 3	.25	17.30	17.75	.0961	.0986
3-inch-wide fiber band:									
4-bag unit. . . .	2	1	2	2	.25	15.08	15.50	.0837	.0861
5-bag unit. . . .	2	1	2	2	.25	15.08	15.50	.0837	.0861
6-bag unit. . . .	2	1	2	2	.25	15.08	15.50	.0837	.0861
24-in-wide shrink film:									
4-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
5-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
6-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
16-inch-wide shrink film:									
4-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
5-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
6-bag unit. . . .	2	1	2	3	.25	17.30	17.75	.0961	.0986
Continuous bags[6]:									
4-bag unit. . . .	0	0	0	2	.25	5.38	5.50	.0298	.0305
5-bag unit. . . .	0	0	0	2	.25	5.38	5.50	.0298	.0305
6-bag unit. . . .	0	0	0	2	.25	5.38	5.50	.0298	.0305

[1] Based on 25 percent of packinghouse supervisor's time allocated to bagging and unitizing operations. [2] Prevailing wage rates including fringe benefits: Bag hangers, check weighers, and bag closers, $2.00 per hour; unitizers, $2.22 per hour; supervisor, $3.75 per hour. [3] Projected wage rates including fringe benefits: Bag hangers, check weighers, and bag closers, $2.00 per hour; unitizers, $2.25 per hour; supervisor $4.00 per hour. [4] Based on pack-out rate of 180 cwt. per hour carried forward to table 16, page 40. [5] 4-bag units require three machines and three operators, 5-bag units and 6-bag units require two machines and three operators. [6] Automatic bag forming, filling, and sealing operation requires only two men.

The equipment evaluated was that used in the bagging and banding operations. There was nothing in these operations that would change the work flow or operations that take place before the potatoes are bagged. The bagging operations are the same for three unitizing methods, but different for the continuous-bag method. Since the equipment used for the continuous-bag method of unitizing was part of the bag-filling operation, the cost of the bagging equipment was included in the cost of unitizing by this method (tables 5 and 6).

The extra floor space needed to accommodate the banding equipment is not great—a maximum of 300 square feet for the continuous-bag method, which requires the most space. The leased cost of this amount of space, based on a pack-out rate of 180 cwt. per hour, was $0.00102 per cwt. Because this cost is so small, it is included as part of the overhead costs shown in table 16.

Arrival of Shipment at Terminal Market

The shipment from Burley, Idaho, arrived at a warehouse in Chicago on January 11, 1968. The truck was held unopened until the research workers arrived. An inspection of the condition of the potatoes was made by the United States Department of Agriculture's Fresh Products Standardization and Inspection Branch representatives.

TABLE 5.—Annual ownership and operating costs of equipment for unitizing 10-pound polyethylene bags of potatoes, Idaho, 1968

Equipment	Equipment cost[1]	Expected life	Annual cost of ownership: Depreciation	Annual cost of ownership: Interest, 3%[2]	Annual cost of ownership: Insurance and taxes, 2%	Annual cost of ownership: Total	Annual cost of operation: Power	Annual cost of operation: Maintenance, 1.5%	Annual cost of operation: Total	Total annual cost	Assumed use per year	Cost per hour
Depreciation	*Dollars*	*Year*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Hours*	*Dollars*
Baker bagger (14 head) .	12,000.00	10	1,200.00	360.00	240.00	1,800.00	192.00	180.00	372.00	2,172.00	1,800	1.207
Polyethylene bag closer .	1,200.00	10	120.00	36.00	24.00	180.00	24.01	18.00	42.01	222.01	1,800	.123
Double belt conveyor. .	881.25	8	110.15	26.44	17.63	154.22	24.01	13.22	37.23	191.45	1,800	.106
Avistrapper APM-2 . . .	7,475.00	10	747.50	224.25	149.50	1,121.25	24.01	112.13	136.14	1,257.39	1,800	.699
Model 37 - Form, fill, and seal (Bodolay) .	40,000.00	10	4,000.00	1,200.00	800.00	6,000.00	144.00	600.00	744.02	6,744.02	1,800	3.747
Shrink tunnel .	7,500.00	10	750.00	225.00	150.00	1,125.00	288.00	112.50	400.50	1,525.50	1,800	.848
Form-in-line wrapping machine[3] . .	10,000.00	10	1,000.00	300.00	200.00	1,500.00	145.00	150.00	295.00	1,795.00	1,800	.997

[1] Includes installation costs.
[2] 3 percent of total cost of equipment, or 6 percent of the undepreciated balance.
[3] Special type of equipment to be designed. Costs are estimated.

TABLE 6.—Equipment costs per hundredweight for unitizing 10-pound polyethylene bags of potatoes by banding method and number of bags in unit, one plant, Idaho, 1968[1]

Banding method and number of bags in unit	Type of unitization equipment: Baker bagger 14-head	Polyethylene bag closer	Double belt conveyor	Avistrapper APM-2	Model 37 form, fill, and seal machine	Plastic film shrinking tunnel	Form-in-line wrapping machine	Total cost per cwt.[2]
5/8-inch plastic band:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
4-bag unit	0.0067	0.0006	0.0005	[3] 0.0114				0.019
5-bag unit	.0067	.0006	.0005	[4] .0076				.016
6-bag unit	.0067	.0006	.0005	[4] .0076				.016
3-inch fiber band:								
4-bag unit	.0067	.0006	.0005	.0114				.016
5-bag unit	.0067	.0006	.0005	.0076				.016
6-bag unit	.0067	.0006	.0005	.0076				.016
24-inch shrink film:								
4-bag unit	.0067	.0006	.0005			.0047	.0055	.018
5-bag unit	.0067	.0006	.0005			.0047	.0055	.018
6-bag unit	.0067	.0006	.0005			.0047	.0055	.018
16-inch shrink film:								
4-bag unit	.0067	.0006	.0005			.0047	.0055	.018
5-bag unit	.0067	.0006	.0005			.0047	.0055	.018
6-bag unit	.0067	.0006	.0005			.0047	.0055	.018
Continuous bags:								
4-bag unit					.0208			.021
5-bag unit					.0208			.021
6-bag unit					.0208			.021

[1] Calculated from hourly equipment costs, table 5, above.
[2] Carried forward to table 16, page 40.
[3] Three banding machines needed to keep pace with product flow.
[4] Two banding machines needed to keep pace with product flow.

The trailer was opened and pictures taken of each stack of the load as the unloading progressed. Figures 18 and 19 show the condition of the polyethylene and paper bag units before and after shipment. During the unloading, bundles were selected from each stack in the front and back of the load. Two units of potato bags of each size and type were taken from both the bottom and top layer. These were identified for examination later at four retail stores.

Research workers kept note of the number of damaged units (table 7). Fiber- and plastic-banded units did not arrive in satisfactory condition from the standpoint of broken and loose units. The shrink-film-banded units gave the best results. The continuous bag showed unsatisfactory results from the standpoint of broken bags. However, this could have been caused by the manual closing of the bags and the hand cutting to separate the bags from the strip in which they were fabricated. Mechanization of closing and cutting could reduce or eliminate the number of broken bags.

The condition of the experimental shipment upon arrival at destination was fairly good (fig. 19). Shifting and disarrangement of the units during transit appeared to be minor and not enough to cause significant damage to the bags in the experimental units. Most of the loose and broken units appeared to have been caused by difficulties in handling the units in the adverse conditions under which the trailer was loaded.

Experience gained in loading this experimental shipment indicated that air channels could be incorporated into the load to allow air to circulate through it for ventilation of the product. It was observed that the continuous-bag units, because of their ease of handling and stability, were more adaptable to loading in a pattern with channels to allow air circulation than were the other types of units.

The sample units selected for examination were transported to four stores where the Federal inspectors examined all of the potatoes in each bag in all sample units. The results of this inspection, shown in table 8, indicated that physical damage was negligible and the amount of decay was not above acceptable levels.

TABLE 7.—Handling damage to units and bags in one experimental truck shipment of unitized 10-pound polyethylene bags of potatoes by banding method, number of bags in unit, number of units, and type of damage

Type of banding, number of bags in unit, and number of units	Number of bags inspected	Broken bands	Broken units	Broken bags	Distorted bags[1]	Broken bag seals	Loose units
		Percent of units inspected	*Percent of units inspected*	*Percent of bags inspected*	*Percent of bags inspected*	*Percent of bags inspected*	*Percent of units inspected*
Plastic band:							
4-bag unit (20)	80	0.0	5.0	1.3	0.0	0.0	100.0
5-bag unit (20)	100	0.0	15.0	1.0	0.0	0.0	100.0
6-bag unit (20)	120	0.0	20.0	0.8	0.0	0.0	100.0
Fiber band:							
4-bag unit (20)	80	0.0	5.0	0.0	0.0	0.0	100.0
5-bag unit (20)	100	5.0	5.0	0.0	0.0	0.0	100.0
6-bag unit (20)	120	0.0	5.0	0.8	0.0	0.8	100.0
Shrink film:							
4-bag unit (20)	80	0.0	0.0	0.0	0.0	0.0	0.0
5-bag unit (20)	100	0.0	0.0	0.0	0.0	0.0	0.0
6-bag unit (20)	120	0.0	0.0	0.0	0.0	0.0	10.0
Continuous bags:							
4-bag unit (20)	80	0.0	0.0	1.3	0.0	[2] 8.8	0.0
5-bag unit (20)	100	0.0	0.0	6.0	0.0	[2] 6.0	0.0
6-bag unit (20)	120	0.0	0.0	0.8	0.0	[2] 2.5	0.0

[1] No distortion of bags shown because after bands were cut loose the bags returned to original shape. [2] Broken because of manually cutting bags from strip or manually heat sealing the tops of bags.

BN-36815

BN-36812

BN-36803

BN-36784

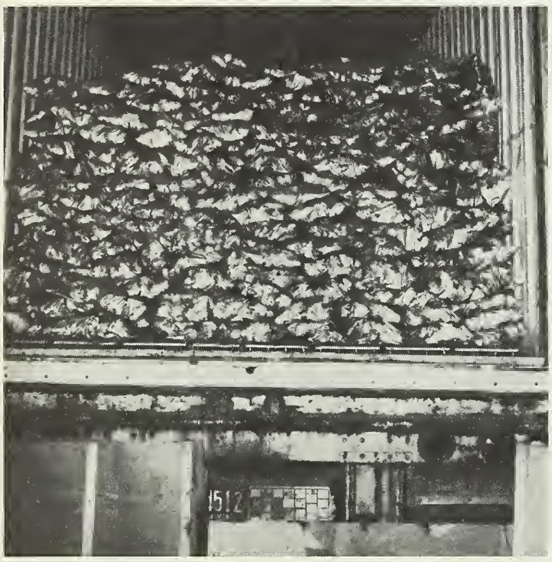
BN-36808

BN-36785

Figure 18.—Paper- and polyethylene-bag units used in test shipments. A, Loading continuous-bag units into truck by conveyor. B, Unloading continuous-bag units from truck at terminal markets. C, Shrink-film-banded units of polyethylene bags before shipment. D, Shrink-film-banded units of polyethylene bags after shipment. E, Fiber-banded units of polyethylene bags after shipment. F, Fiber-banded units of polyethylene bags after shipment.

BN-36787

BN-36796



BN-36801

BN-36791

BN-36813

BN-36802

Figure 19.—Polyethylene- and paper-bag units shown before and after shipment. A, Plastic-film-banded units of polyethylene bags before shipment. B, Plastic-film-banded units of polyethylene bags after shipment. C, Continuous-bag units of polyethylene bags before shipment. D, Continuous-bag units of polyethylene bags after shipment. E, Shrink-film-banded units of paper bags before shipment. F, Shrink-film-banded units of paper bags after shipment.

TABLE 8.–Arrival condition of potatoes in one experimental truck shipment of unitized 10-pound polyethylene bags by type of banding, number of bags in unit, and location in load[1]

Type of banding, number of bags in unit, and location in load	Sample size		Soft rot	Insignificant bruises[2]	Fusarium tuber rot damage		Internal black spot damage	
	Weight	Count			Significant	Insignificant[2]	Significant	Insignificant[2]
Plastic bands:								
Upper tier:	*Ounces*	*Number*	*Percent*		*Percent*		*Percent*	
4-bag unit....	672	103	0	Few........	2	Few........	0	Few.
5-bag unit....	840	138	1	None.......	2	Few........	0	Few.
6-bag unit....	1,036	168	1	None.......	2	Some.......	0	Few.
Lower tier:								
4-bag unit....	680	113	0	Few........	4	Few........	1	Few.
5-bag unit....	852	146	0	Few........	1	Some.......	0	Few.
6-bag unit....	1,024	171	1	Few........	5	Few........	1	Few.
Fiber bands:								
Upper tier:								
4-bag unit....	676	111	2	None.......	1	Few........	0	Few.
5-bag unit....	844	136	2	Some.......	3	Few........	0	Few.
6-bag unit....	1,008	167	0	Few........	3	Few........	0	Few.
Lower tier:								
4-bag unit....	680	104	0	None.......	3	Few........	0	Few.
5-bag unit....	852	131	1	Few........	2	Few........	0	Few.
6-bag unit....	1,016	160	2	Few........	1	Few........	0	Few.
Shrink film:								
Upper tier:								
4-bag unit....	676	99	1	None.......	0	Few........	0	None.
5-bag unit....	836	123	3	None.......	1	Some.......	0	Few.
6-bag unit....	1,008	144	2	Few........	1	Some.......	1	None.
Lower tier:								
4-bag unit....	676	97	1	Few........	2	Few........	1	Few.
5-bag unit....	844	127	0	Few........	9	Few........	0	Few.
6-bag unit....	996	140	0	Few........	1	Some.......	1	Few.
Consumer bags:								
Upper tier:								
4-bag unit....	636	111	0	Few........	0	Few........	0	Few.
5-bag unit....	834	144	0	Few........	2	Few........	0	None.
6-bag unit....	1,008	162	0	None.......	0	Few........	0	Few.
Lower tier:								
4-bag unit....	716	123	0	Few........	3	Few........	0	None.
5-bag unit....	844	134	0	None.......	2	Few........	1	Few.
6-bag unit....	1,012	143	0	Few........	0	Few........	0	None.

[1] Contents of this table taken from Condition Inspection Certificate written by USDA Inspection personnel.
[2] Minor damage that is not scorable for purposes of determining U.S. grade.

SHIPMENT OF POTATOES IN PAPER BAGS FROM THE RED RIVER VALLEY

With the aid of personnel from the Red River Valley Potato Research Center, Grand Forks, Minn., plants in the Red River Valley potato area were visited to study packinghouse layouts and methods of operation. A large potato packing and shipping firm in Oslo, Minn., cooperated

in making the experimental shipment of potatoes in paper bags, which was consigned to a receiver-distributor in Urbana, Ill.

Layout of the Plant and Description of Operations at the Shipping Point

The cooperating shipper's facilities were typical of most large plants in the area. They were housed in a relatively new steel building, and the packing-line equipment was laid out for an efficient packing operation. The packing line, which had a pack-out capacity of approximately 200 tons a day, used a 14-head Baker bagger. The potato-sizing equipment, which sorted the potatoes by their largest diameters, had a sufficient capacity to handle the output of potatoes from two sorting tables. Any or all of the three sizes into which the potatoes were sorted could go on to the bagging machine or be diverted to sacking sections.

The main sizing equipment was on the first floor of the plant, with conveyor belts carrying the sized potatoes up to a mezzanine where they were bagged with the Baker bagger.

Units for the test shipment were prepared on the mezzanine floor. The completed units were stacked on semilive skids for temporary storage and subsequent handling. When ready for shipment, the bundles were placed on a retractable belt conveyor and conveyed directly into the truck. The conveyor was then pulled back after the load was completed.

A total of 240 test units, consisting of 20 each of the three sizes (four-, five-, and 6-bag units) unitized by each of the four banding methods were included in the experimental shipment. The test units were stacked in the top and bottom layers of the load in the same patterns and the same locations as the test units of polyethylene film bags in the previously described experimental shipments from Idaho.

Cost Evaluations

As in the experimental shipment from the Pacific Northwest, cost data were obtained from cooperating shippers in the area whose wage rates and pack-out rates were similar to those in the packinghouse from which the experimental shipment was made. The overhead and other items of cost were supplied by the shipper who cooperated in packing and shipping the experimental units.

Materials Cost Evaluation

The cost of materials for banding the 10-pound bags of potatoes (table 9) was highest for shrink film and lowest for the fiber band.

Labor Cost Evaluation

Labor costs in the Red River Valley were lower than in the Pacific Northwest. Bag handlers, checkers, and bag closers received \$1.51 an hour (table 10) including social security, compared with the \$1.94 in Idaho. Workers doing unitizing received \$1.62 an hour and the supervisor \$2.70. The cost for packaging and unitizing operations for paper bags in the Red River Valley was \$0.017 per cwt. less than for polyethylene bags in Idaho.

The pack-out rate at the cooperating shipper's plant was sufficient to keep the Baker bagger running at full capacity. Full-capacity operation was difficult, however, because the installation did not have holding bins for accumulating reserve supplies of potatoes to act as a buffer between the grading line and the bagging operation. In most packinghouses there was a small buffer bin, which at times overflowed, requiring adjustment and slowdown of the main sizing and grading line. However, the bagging and unitizing operations operated at the output rate of the Baker bagger unit—180 hundredweight or 9 tons per hour. Labor costs calculated at this pack-out rate for each size of unit and each method of banding are shown in table 11. These costs are calculated from wage data given in table 10.

Equipment Cost Evaluation

The evaluation of equipment costs for the bagging and unitizing operations does not include the equipment used in packing-line operations before the potatoes are bagged. The rate of output of the bagging operation controls the output of units of bags. Therefore, the data in tables 12 and 13 that give equipment cost comparisons for unitizing paper bags are presented in the same way as the data given in tables 5 and 6 for polyethylene bags.

It seems probable that a continuous paper-bagging operation on a form-and-fill basis will not materialize because of the cumbersomeness and cost of the required paper-bag-making equipment. Continuous paper bags could be made as in the test when the paper bags were glued to two strips of fiber banding material. It

TABLE 9.–Material costs for bagging and unitizing 10-pound paper bags of potatoes by banding method and number of bags in unit, Red River Valley, Minn., 1968

Banding method	Bag cost[1]	Banding material cost	Banding material cost per unit			Total material cost per unit[2]			Total material cost per cwt.[3]		
			4-bag unit	5-bag unit	6-bag unit	4-bag unit	5-bag unit	6-bag unit	4-bag unit	5-bag unit	6-bag unit
	Dollar	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*	*Dollar*
5/8-inch-wide plastic bands	0.0445	0.0054/ft.	0.0468	0.0522	0.0576	[5]0.2248	[5]0.2747	[5]0.3246	0.5620	0.5494	0.5410
3-inch-wide fiber band	.0445	.00654/ft.	.0280	.0320	.0350	.2060	.2545	.3020	.5150	.5090	.5033
24-inch-wide shrink film.	.0445	.00007/sq. in.	.0800	.0890	.0990	.2580	.3115	.3660	.6450	.6230	.6100
16-inch-wide shrink film.	.0445	.00007/sq. in.	.0580	.0650	.0720	.2360	.2875	.3390	.5900	.5750	.5650
Continuous bags	.0445	[4].00654/ft.	.0479	.0577	.0676	.2259	.2802	.3346	.5647	.5604	.5576

[1]Bag cost based on quantity order of 100,000 bags.
[2]Total cost per unit includes bags and banding materials. Carried forward to table 16, page 40.
[3]Sample calculations:

4-bag unit: $\frac{0.2248}{0.40} = 0.5620$

5-bag unit: $\frac{0.2747}{0.50} = 0.5494$

6-bag unit: $\frac{0.3246}{0.60} = 0.5410$

[4]Three-inch-wide kraft paper tape used to make continuous bags–two strips required.
[5]Sample calculations:

Four-bag unit $0.0445 x 4 + $0.0468 = $0.2248
Five-bag unit $0.0445 x 5 + $0.0522 = $02747
Six-bag unit $0.0445 x 6 + $0.0576 = $0.3246

TABLE 10.–Number of workers, hourly rates, and labor costs per hundredweight for bagging and unitizing 10-pound paper bags of potatoes by type of labor, Red River Valley, Minn., 1968

Type of labor	Hourly wage[1]	Operational hrs./yr.	Yearly wage	Number of people	Total annual wage	Cost per cwt. @ 180 cwt./hr.
	Dollars	*Hours*	*Dollars*	*Number*	*Dollars*	*Dollars*
Bag hanger	1.51	1,400	2,114	2	4,228	0.0168
Check weigher . . .	1.51	1,400	2,114	1	2,114	.0084
Bag closer.	1.51	1,400	2,114	2	4,228	.0168
Bag unitizer	1.62	1,400	2,268	1	2,268	.0090
Supervisor	2.70	[2] 350	945	1	945	.0038
Total					13,783	.0548

[1] Wage rates include fringe benefits.
[2] Based upon 25 percent of supervisor's time allocated to bagging operation.

TABLE 11.–Crew size and labor costs for bagging and unitizing 10-pound bags of potatoes by type of banding method and number of bags per unit, one plant, Red River Valley, Minn., 1968

Banding method	Crew size					Total hourly labor cost		Total hourly labor cost per cwt.[4]	
	Bag hanger	Check weigher	Bag closer	Bag unitizer	Supervisor[1]	At prevailing wage rates[2]	At projected wage rates[3]	At prevailing wage rates	At projected wage rates
5/8-inch-wide plastic band:	*Number*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
4-bag unit. . . .	2	1	2	[5]3	0.25	13.08	17.75	0.0726	0.0986
5-bag unit. . . .	2	1	2	[5]3	.25	13.08	17.75	.0726	.0986
6-bag unit. . . .	2	1	2	[5]3	.25	13.08	17.75	.0726	.0986
3-inch-wide fiber band:									
4-bag unit. . . .	2	1	2	2	.25	11.46	15.50	.0636	.0861
5-bag unit. . . .	2	1	2	2	.25	11.46	15.50	.0636	.0861
6-bag unit. . . .	2	1	2	2	.25		15.50	.0636	.0861
24-inch-wide shrink film:									
4-bag-unit. . . .	2	1	2	3	.25	13.08	17.75	.0726	.0986
5-bag-unit. . . .	2	1	2	3	.25	13.08	17.75	.0726	.0986
6-bag-unit. . . .	2	1	2	3	.25	13.08	17.75	.0726	.0986
16-inch-wide shrink film:									
4-bag-unit. . . .	2	2	2	3	.25	14.59	19.75	.0810	.1097
5-bag-unit. . . .	2	2	2	3	.25	14.59	19.75	.0810	.1097
6-bag-unit. . . .	2	2	2	3	.25	14.59	19.75	.0810	.1097
Continuous bags[6] .	–	–	–	–	–	–	–	–	–

[1]Based on 25 percent of packinghouse supervisor's time allocated to packaging and unitizing operation. [2]Prevailing wage rates including fringe benefits: Bag hangers, check weighers, and bag closers, \$1.51 per hour; unitizers, \$1.62 per hour; supervisor, \$2.70 per hour. [3]Projected wage rates including fringe benefits: Bag hangers, check weighers, and bag closers, \$2.00 per hour; unitizers, \$2.25 per hour; supervisor, \$4.00 per hour. [4]Based on pack-out rate of 180 cwt. per hour carried forward to table 17, page 40. [5]Four-bag units require three banding machines and three operators; five- and 6-bag units require two banding machines and three operators. [6]No equipment available for automatic forming, filling, and unitizing continuous paper bags.

TABLE 12.–Annual ownership and operating costs of equipment for bagging and unitizing 10-pound paper bags of potatoes, Red River Valley, Minn., 1968

Equipment	Equipment cost[1]	Expected life	Annual cost of ownership				Annual cost of operation			Total annual cost	Assumed use per year	Cost per hour
			Depreciation	Interest, 3% [2]	Insurance and taxes, 2%	Total	Power	Maintenance, 1.5%	Total			
Description	*Dollars*	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Hours*	*Dollars*
Baker bagger (14 head). . .	12,000.00	10	1,200.00	360.00	240.00	1,800.00	192.00	180.00	372.00	2,172.00	1,400	1.551
Sewing machine	1,510.00	10	151.00	45.30	30.20	226.50	24.01	22.65	46.66	273.16	1,400	.195
Double belt conveyor . . .	881.25	8	110.15	26.44	17.63	154.22	24.01	13.22	37.23	191.45	1,400	.137
Avistrapper AMP-2	7,475.00	10	747.50	224.25	149.50	1,121.25	24.01	112.13	136.14	1,257.39	1,400	.898
Shrink tunnel. .	7,500.00	10	750.00	225.00	150.00	1,125.00	288.00	112.50	400.50	1,525.50	1,400	1.089
Form-in-line wrapping machine[3] . . .	10,000.00	10	1,000.00	300.00	200.00	1,500.00	145.00	150.00	295.00	1,795.00	1,400	1.282

[1] Includes installation costs. [2] Three percent of total cost of equipment, or 6 percent of the undepreciated balance.
[3] Special type of equipment to be designed. Costs are estimated.

TABLE 13.–Equipment costs per hundredweight for bagging and unitizing 10-pound paper bags of potatoes by type of banding method and size of unit, one plant, Red River Valley, Minn., 1968[1]

Banding method	Type of unitization equipment						Total equipment cost per cwt.[2]
	Baker bagger, 14-head	Bag sewing machine	Double belt conveyor	Avistrapper model APM-Z	Heat-shrinking tunnel	Form-in-line wrapping machine	
5/8-inch-wide plastic band:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
4-bag-unit	0.0086	0.0011	0.0008	[3] 0.0150	–	–	0.025
5-bag-unit	.0086	.0011	.0008	[4] .0100	–	–	.020
6-bag-unit	.0086	.0011	.0008	[4] .0100	–	–	.020
3-inch-wide fiber band:							
4-bag-unit	.0086	.0011	.0008	[4] .0100	–	–	.020
5-bag-unit	.0086	.0011	.0008	[4] .0100	–	–	.020
6-bag-unit	.0086	.0011	.0008	[4] .0100	–	–	.020
24-inch-wide shrink film:							
4-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
5-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
6-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
16-inch-wide shrink film:							
4-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
5-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
6-bag-unit	.0086	.0011	.0008	–	.0061	.0071	.024
Continuous bags[5]	–	–	–	–	–	–	–

[1] Calculated from hourly equipment costs, table 12, page 34. [2] Carried forward to table 17, page 40. [3] Three banding machines needed to keep pace with product flow. [4] Two banding machines needed to keep pace with product flow. [5] No equipment available for forming continuous paper bags.

should also be possible to take conventionally bagged paper bags of potatoes and mechanically attach them to two strips of continuous banding material. However, the paper bags may tear when the bands are removed at retail. This method of making a continuous bag would accomplish almost exactly the same purpose as the use of fiber bands to unitize the bags.

For the reasons indicated, a comparison of the difference in cost for unitizing the 10-pound bags of the four types could be done without including the bagging equipment. Bagging equipment was included so that the evaluation for the paper bags would be comparable with that for the polyethylene bags shipped from the Pacific Northwest.

Arrival of Shipment at Terminal Market

The shipment from Oslo, Minn., arrived in Urbana, Ill., on February 12, 1968. Arrangements had been made in advance for the same inspectors of the U.S. Department of Agriculture who evaluated the test shipment of Idaho potatoes in polyethylene film bags to evaluate arrival condition of the potatoes. Photographs were made of each stack as unloading of the shipment progressed, and the units from the bottom and top layers were selected for examination for damage. The amount and type of damage sustained by the units and the individual bags during transport and handling are summarized in table 14. The condition of the units and the paper bags before and after shipment is shown in figure 20. The selected units were shipped to a retail store where all of the potatoes in all of the bags in each unit were examined. Data on the damage to and condition of the potatoes in the bags in each type and size of unit upon delivery to the store is given in table 15.

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BN-36806

Figure 20.—Paper-bag units shown before and after test shipment. A, Fiber-banded units of paper bags before shipment. B, Fiber-banded units of paper bags after shipment. C, Plastic-banded units of paper bags before shipment. D, Plastic-banded units of paper bags after shipment. E, Continuous-bag units of paper bags before shipment.

TABLE 14.—Handling damage to units and bags in one experimental truck shipment of unitized 10-pound paper bags of potatoes by type of banding and size of unit, and by type of damage

Type of banding, size of unit, and number of bags per unit	Number of bags inspected	Broken bands	Broken units	Broken bags	Distorted bags	Broken bag seals	Loose units
		Percent of units inspected	*Percent of units inspected*	*Percent of bags inspected*	*Percent of bags inspected*	*Percent of bags inspected*	*Percent of units inspected*
Plastic band:							
4-bag-unit (20)......	80	5.0	5.0	0.0	0.0	0.0	100.0
5-bag-unit (20)......	100	0.0	5.0	1.0	0.0	0.0	100.0
6-bag-unit (20)......	120	0.0	10.0	0.0	0.0	0.0	100.0
Fiber band:							
4-bag-unit (20)......	80	0.0	0.0	1.3	0.0	0.0	100.0
5-bag-unit (20)......	100	0.0	5.0	0.0	0.0	0.0	100.0
6-bag-unit (20)......	120	5.0	0.0	0.0	0.0	0.8	100.0
Shrink film:							
4-bag-unit (20)......	80	0.0	0.0	0.0	0.0	0.0	5.0
5-bag-unit (20)......	100	0.0	0.0	1.0	0.0	0.0	5.0
6-bag-unit (20)......	120	0.0	0.0	0.0	0.0	0.0	5.0
Continuous bags:							
4-bag-unit (20)......	80	0.0	0.0	2.5	0.0	0.0	0.0
5-bag-unit (20)......	100	0.0	15.0	0.0	0.0	0.0	0.0
6-bag-unit (20)......	120	0.0	15.0	0.0	0.0	0.0	0.0

TABLE 15.—Arrival condition of potatoes in one experimental truck shipment of unitized 10-pound paper bags by type of banding, number of bags in unit, and location in load[1]

Banding method and location	Sample size		Soft rot	Insignificant bruises	Slightly sunken discolored areas		Fusarium tuber rot damage	
	Weight	Count			Significant	Insignificant[2]	Significant	Insignificant[2]
Plastic bands:								
Upper tier:	*Ounces*	*Number*	*Percent*		*Percent*		*Percent*	
4-bag unit...	645	100	0	None	2	Few	None	None.
5-bag unit...	814	123	0	Few	0	Few	None	None.
6-bag unit...	963	151	0	Few	0	Few	Some	None.
Lower tier:								
4-bag unit...	651	97	0	Few	2	None	None	None.
5-bag unit...	801	124	0	Few	2	None	None	None.
6-bag unit...	952	153	0	Few	1	Few	None	None.
Fiber bands:								
Upper tier:								
4-bag unit...	646	110	0	Few	1	Few	None	None.
5-bag unit...	927	184	0	Few	0	Few	None	None.
6-bag unit...	956	213	0	Few	0	Few	Few	None.
Lower tier:								
4-bag unit...	646	110	0	Few	1	Few	None	None.
5-bag unit...	808	165	0	Few	0	Few	None.......	None.
6-bag unit...	982	229	0	Few	1	Few	None	None.

TABLE 15.–Arrival condition of potatoes in one experimental truck shipment of unitized 10-pound paper bags by type of banding, number of bags in unit, and location in load[1] –Continued

Banding method and location	Sample size		Soft rot	Insignificant bruises	Slightly sunken disclored areas		Fusarium tuber rot damage	
	Weight	Count			Significant	Insignificant[2]	Significant	Insignificant[2]
Shrink film:								
Upper tier:	*Ounces*	*Number*	*Percent*		*Percent*		*Percent*	
4-bag unit...	647	121	0	None	1	None	None	None.
5-bag unit...	814	147	0	None	0.5	Some	None	None.
6-bag unit...	972	135	0	Few	Less than 1	Some	None	None.
Lower tier:								
4-bag unit...	667	130	0	Some	0.5	Some	Some	Some.
5-bag unit...	818	129	0	Some	0	Some	None	None.
6-bag unit...	984	138	0	Some	Less than 1	None	None	None.
Continuous bags:								
Upper tier:								
4-bag unit...	--	--	0	Few	2	Few	None	None.
5-bag unit...	--	--	0	Few	0.5	None	None	Few.
6-bag unit...	--	--	0	Few	0.5	Few	Few	None.
Lower tier:								
4-bag unit...	--	--	0	Few	0	Few	None	None.
5-bag unit...	--	--	0	Few	0.5	Few	None	None.
6-bag unit...	--	--	0	Few	0	Few	None	None.

[1] Contents of this table taken from Condition Inspection Certificate written by USDA Inspection Personnel.
[2] Minor damage that is not scorable for purposes of determining U.S. grade.

DISCUSSION

The slippery surface of the film bags and the plastic banding materials prevented success of some methods of banding and eliminated them from consideration for commercial application.

It was apparent that the length of the bag had an important effect on the success of the banding method; the long bags were banded more easily than the short bags.

Polyethylene shrink film required a temperature for shrinking that caused some bags to adhere to the shrink film. Thus, the use of polyethylene shrink film proved impractical. However, with the use of polyvinyl film, the difference in shrink temperature of the two types of film is great enough to prevent sticking of the banding material to the bags. The second way of using the polyethylene shrink film was to extend the film over the ends of the bags so that the ends could be shrunk without raising the temperature of the bag material sufficiently to cause the overwrapped film to adhere to the bags. This method required a wider film and increased the cost of unitizing.

The use of continuous bags seemed to have more potential as a method of unitizing the bags than the other methods, particularly where automatic filling equipment might be used. The main handicap of this technique is the need to cut the bags apart at retail. However, because of the potential savings, the use of continuous bags may still be worthwhile. The bags could be produced with tear strips which would make separation of bags at retail easier.

The paper bags posed no problem when shrink film was used for unitizing. The continuous-bag method for kraft paper bags was less satisfactory. Because there is no really adaptable equipment for making kraft paper bags in continuous strips, expensive development work would be necessary. The development work may be uneconomical, because the kraft bags appear

to be decreasing considerably in market popularity.

The test shipments disclosed some practical aspects of handling the unitized bags. It was found that the slippery nature of unitized bags made pallet handling difficult, except for the continuous-bag units which could be overlapped and cross-tied in a compact, stable stacking pattern on the pallets. In full commercial operation, it would certainly be desirable to use pallets equipped with side racks to hold the units on the pallet base instead of conventional warehouse pallets. The unitized bags handled well on belt conveyors. All of the units gave acceptable payloads in truck shipments with enough space between them to allow adequate air circulation through the loads.

The workers did not object to handling the bundles in these small tests, but their attitude might change in the long run. It was noted that there was a tendency for the workers to handle the bundles more gently when they were encircled with the film. An attempt was made to have the film sufficiently strong that the bundles could be handled by holding onto the film. The workers grasped the whole bundle, however, rather than the film. When the units were banded with plastic straps, workers often grasped the bundle by the straps. They apparently thought that the clear plastic film was not as strong as the fiber bands.

The shippers contacted in this research were quite interested in the possibilities of making cost reductions in their operations. Such possibilities seemed to be their incentive to cooperate on the project.

Commercial unitizing equipment that can be readily adapted to strapping the units of bags is available. The strapping equipment is similar to the tying equipment that has been in use for several years for certain industrial applications. One version that handles plastic strapping similar to that used in the study has recently been developed. This equipment could be modified to enable it to handle the fiber bands for unitizing the bags.

Form-and-fill equipment is commercially available for packing 5-pound film bags and is being developed by manufacturers for 10-pound bags. However, neither type of equipment will form the bags into continuous bag units.

The shrink-film method of unitizing the bags probably can be done mechanically. Form-in-line packaging equipment to put the shrink film around the units can be adapted to unitizing the bags. Such equipment could be combined with the necessary conveyors and commercially available heat tunnels for shrinking the film.

The results show that the continuous-bag type of unitizing is by far the least costly. For film bags, this method of unitizing is \$0.30 to \$0.50 per hundredweight less expensive than other methods. The continuous bags can provide sizable reductions in materials and labor costs with only very small increases in equipment costs (table 16).

The costs per hundredweight for unitizing kraft-paper bags are shown in table 17. The difference in costs between the methods of unitizing is not so great for the kraft-paper bags as for the polyethylene film bags. While the kraft-paper bags were unitized at a lower cost than the film bags, this difference results entirely from a lower labor cost in the area in which the unitizing of the paper bags was studied. When wage rates are equalized by using \$2.00 as the hourly wage for general labor, \$2.25 for workers doing unitizing, and \$4.00 for supervisors, it becomes apparent that it costs 16 to 17 cents more per cwt. to buy and unitize paper bags than it does for film bags (tables 16 and 17).

TABLE 16.–Total costs per hundredweight for bagging and unitizing 10-pound polyethylene bags of potatoes by method of banding and size of unit, Ida., 1968

Banding method	Direct costs per cwt.				General administration and overhead[4]	Total cost per cwt.	
	Materials cost[1]	Labor cost[2]	Equipment cost[3]	Total		Prevailing wage rate	Projected wage rate[5]
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
5/8-inch-wide plastic band:							
4-bag unit	0.448	0.096	0.019	0.563	0.242	0.805	0.811
5-bag unit	.435	.096	.016	.547	.235	.782	.788
6-bag unit	.427	.096	.016	.539	.232	.771	.777
3-inch-wide fiber band[6]:							
4-bag unit	.401	.084	.016	.501	.215	.716	.721
5-bag unit	.395	.084	.016	.495	.213	.708	.712
6-bag unit	.389	.084	.016	.489	.210	.699	.704
24-inch-wide shrink film:							
4-bag unit	.531	.096	.018	.645	.277	.922	.928
5-bag unit	.509	.096	.018	.623	.268	.891	.897
6-bag unit	.496	.096	.018	.610	.262	.872	.878
16-inch-wide shrink film:							
4-bag unit	.476	.096	.018	.590	.254	.844	.849
5-bag unit	.461	.096	.018	.575	.247	.822	.828
6-bag unit	.451	.096	.018	.565	.243	.808	.814
Continuous bags:							
4-bag unit	.230	.030	.021	.281	.121	.402	.405
5-bag unit	.230	.030	.021	.281	.121	.402	.405
6-bag unit	.230	.030	.021	.281	.121	.402	.405

[1] Taken from table 2, page 25. [2] Taken from table 4, page 26. [3] Taken from table 6, page 27. [4] Calculated at 43 percent of total direct costs per cwt. [5] Calculated on basis of labor rates at $2.00 for normal labor, $2.25 for unitizers, and $4.00 for supervisor. [6] Assume same banding equipment used for plastic bands.

TABLE 17.–Total costs per hundredweight for bagging and unitizing 10-pound paper bags of potatoes, one plant, Red River Valley, Minn., 1968

Banding method	Direct costs per cwt.[4]				General administration and overhead[5]	Total cost per cwt.	
	Materials cost[1]	Labor cost[2]	Unitizing equipment cost[3]	Total		Prevailing wage rate	Projected wage rate[6]
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
5/8-inch-wide plastic band:							
4-bag unit	0.562	0.073	0.025	0.660	0.284	0.944	0.974
5-bag unit	.549	.073	.020	.642	.276	.918	.951
6-bag unit	.541	.073	.020	.634	.273	.907	.940
3-inch-wide fiber band[7]:							
4-bag unit	.515	.064	.020	.599	.258	.857	.884
5-bag unit	.509	.064	.020	.593	.255	.848	.875
6-bag unit	.503	.064	.020	.587	.252	.839	.867
24-inch-wide shrink film:							
4-bag unit	.645	.073	.024	.742	.319	1.061	1.091
5-bag unit	.623	.073	.024	.720	.310	1.030	1.060
6-bag unit	.610	.073	.024	.707	.304	1.011	1.041
16-inch-wide shrink film:							
4-bag unit	.590	.073	.024	.687	.295	.982	1.012
5-bag unit	.575	.073	.024	.672	.289	.961	.991
6-bag unit	.565	.073	.024	.662	.285	.947	.977
Continuous bags[8]:							
4-bag unit	.565	–	–	–	–	–	–
5-bag unit	.560	–	–	–	–	–	–
6-bag unit	.558	–	–	–	–	–	–

[1] Taken from table 9, page 33. [2] Taken from table 11, page 34. [3] Taken from table 13, page 35. [4] Labor and equipment costs are calculated on basis of 1,800 annual operational hours to compare with polyethylene bagging operation.
[5] Calculated at 43 percent of total direct costs per cwt. [6] Calculated on basis of labor rates at $2.00 for normal labor, $2.25 for unitizers, and $4.00 for supervisor. [7] Assume same type of banding equipment used for fiber bands and plastic bands. [8] No equipment available for bagging continuous paper bags.

COMPARATIVE COSTS—EXPERIMENTAL METHODS VS. EXISTING METHODS

The existing methods of unitizing the film and kraft paper bags for transport and handling consist of using multiwall kraft paper bags or corrugated fiberboard boxes as master containers to carry five 10-pound bags. During the study, data on the costs of using these methods were gathered in packinghouses in the same area from which the experimental shipments of the unitized lots were made. These costs, together with the costs for the two most promising experimental methods, are shown in table 18.

A comparison of the cost data for the experimental continuous-bag unitizing method and the lower cost existing method (baler bag) indicates that a saving of 50 cents or more per hundredweight can be saved by using the continuous-bag unitizing method. This saving would be a substantial one for the potato packers and distributors.

TABLE 18.—Cost per hundredweight for bagging 10-pound polyethylene bags of potatoes and unitizing them into 5-bag units by selected experimental and existing methods, one plant, Ida., 1968

Cost element	Existing methods		Experimental methods		
	Baler bag	Carton	Shrink film		Continuous bags
			24 in. wide	16 in. wide	
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Cost of 10-pound bags	[1] 0.331	[1] 0.331	[1] 0.331	[1] 0.331	[2] 0.230
Cost of unitizing materials	[3] .202	[4] .540	[5] .178	[5] .130	[9] (6)
Labor cost[7]	[8] .096	[8] .096	[8] .096	[8] .096	[9] .030
Unitizing equipment ownership and operation	.009	.013	[10] .018	[10] .018	[10] .021
Total cost—material, labor, and equipment	.638	.980	.623	.575	.281
General admin. overhead 43% of total cost	.274	.421	.268	.247	.121
Total cost per cwt.	.912	1.401	.891	.822	.402

[1] Based on 100,000 quantity order of bags @ $33.05/M. [2] Based on $0.023/bag charged to Food Industries Research and Engineering by fabricator. [3] Based on quantity order of 20,000 bags @ $100.45/M. [4] Based on quantity order of 20,000 cartons @ 27¢ per carton. [5] Based on $0.00007 per square inch of material. [6] No materials necessary—continuous bags self-contained. [7] Hourly wage of $1.94 for general labor, $2.22 for unitizing labor, and $3.75 for supervisor. [8] Based on eight workers and one supervisor for bagging operation. [9] Based on automatic equipment needing two workers and one supervisor. [10] Taken from table 16, page 40.

CONCLUSIONS

Because of the increasing cost of labor and the reluctance of labor to handle continuous heavy work, the future will see more and more activity directed toward reducing labor requirements in the packing and handling of potatoes. The findings of this study will aid in that endeavor.

The most important finding of the study is the cost-reducing potential of the continuous-bag method of unitizing consumer-size bags of potatoes. Further work needs to be done on the filling applications and marketing aspects of this method. Means of separating the bags at retail need to be developed. The continuous-bag units were highly adaptable to palletization, making compact, stable palletized units which allow good use of transport and storage space. The individual units handled well on conveyors and could be easily loaded in a way that allows for good ventilation during transport.

The next most promising method studied was the use of shrink film to bundle the units together. In this method, the film was shrunk only at the ends of the units to prevent the bags from slipping out of the bundle.

The four-bag units had some advantages over five- and six-bag units, since their lighter weight made them easier to handle. The four-bag units squared up better on pallets than the five-bag units. Although the six-bag unit squared up well, the weight was greater and handling somewhat more difficult. There was a 2- to 5-cent saving for the six-bag unit over the four-bag unit, which might be significant in choosing the size of unit to be used for a particular packaging and marketing application.

Unitizing the bags by the methods studied in this research could be done semiautomatically, and the shrink-film unitizing and the continuous-bag unitizing could be completely automatic. The major problem with the continuous-bag method is to find a quick and convenient means of separating the bags in the units at retail.

Although the results of this study apply directly to the 10-pound bags of potatoes, they suggest that similar economies might also be achieved in using these methods to unitize 5-pound bags of potatoes.

The results of this study also suggest that the continuous-bag method of unitizing consumer-size bags may have some cost-reducing potential in packing, transport, and handling of consumer-size bags of other commodities such as onions, oranges, and carrots, and possibly grapefruit. However, additional research should be done to determine whether this technique could be adapted to the needs of these products.